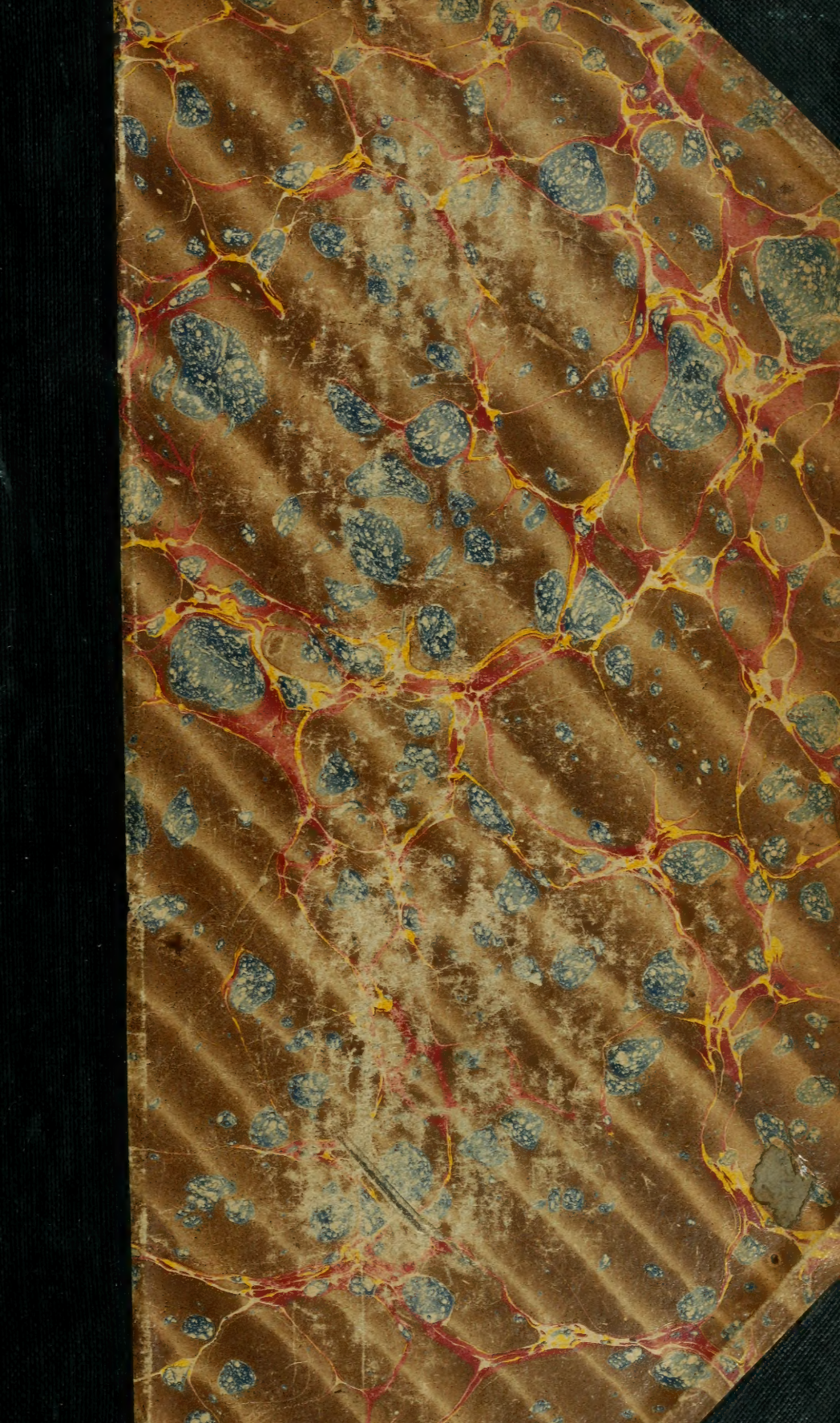

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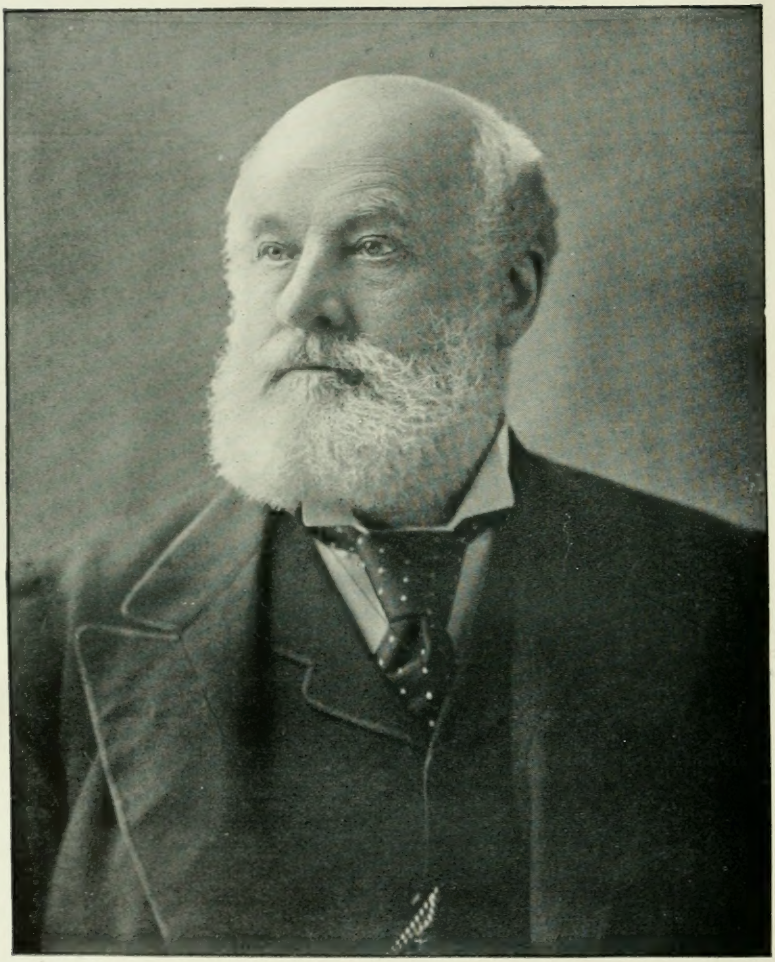

THOMAS JOHN BEWICK.

Born on October 28th, 1821, and died on August 29th, 1897.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS

VOL. XLVII.

1897–98.

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NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 7TH, 1897.

MR. THOMAS DOUGLAS, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on July 24th and that day.

The SECRETARY also reported the proceedings of the Council of The Federated Institution of Mining Engineers.

ELECTION OF OFFICERS.

The CHAIRMAN appointed Messrs. W. C. Cockburn, J. Cook, R. Laverick, and T. Lowden as scrutineers of the balloting-papers for the election of officers for the year 1897-98. The scrutineers afterwards reported the result of the ballot as follows:—

PRESIDENT.

MR. GEORGE MAY.

VICE-PRESIDENTS.

MR. W. ARMSTRONG.
MR. T. W. BENSON.
MR. C. BERKLEY.
SIR W. T. LEWIS.
MR. R. ROBINSON.
MR. W. O. WOOD.

COUNCIL.

MR. HENRY AYTON.
MR. R. DONALD BAIN.
MR. J. R. CRONE.
MR. T. E. FORSTER.
MR. T. Y. GREENER.
MR. T. E. JOBLING.
MR. A. C. KAYLL.
MR. H. LAWRENCE.
MR. C. C. LEACH.
MR. W. LOGAN.
MR. HENRY LOUIS.
MR. J. H. MERIVALE.
MR. H. PALMER.
MR. A. M. POTTER.
MR. H. RICHARDSON.
MR. F. R. SIMPSON.
MR. JOHN SIMPSON.
MR. R. L. WEEKS.

The CHAIRMAN proposed a vote of thanks to the Vice-Presidents, Councillors, Treasurer, and Secretary for their services during the past year, which was agreed to.

The CHAIRMAN moved, and Mr. M. WALTON BROWN seconded, that a vote of thanks be accorded to the scrutineers for their services, which was agreed to.

The CHAIRMAN referred to the honour of a baronetcy which had been conferred upon one of their members and a Past-President, Sir Lindsay Wood. Those who had been associated with that gentlemen for a number of years would feel that this honour was a recognition of services so well rendered to the coal trade, and with great pleasure he proposed that the Secretary be desired to convey to Sir Lindsay Wood the congratulations of the members on the honour which had been conferred upon him.

Mr. J. B. SIMPSON, in seconding the proposal, endorsed most heartily the remarks of the Chairman. The members admired Sir Lindsay Wood, and were under great obligations to him, even if it were only for the position which he had taken up in connexion with this Institute. He was one of the oldest members, and had always taken a lively interest in its welfare, and had read some valuable papers, which had been printed in the *Transactions*.

The vote of congratulation was adopted.

The SECRETARY read the Annual Report of the Council as follows:—

ANNUAL REPORT OF THE COUNCIL, 1896-97.

The following table shows the numbers of members of various classes during a few recent years:—

	August 1st.		
	1895.	1896.	1897.
Honorary Members...	26	23	29
Members	717	767	829
Associate Members	67	78	98
Associates	67	83	91
Students	36	46	45
Subscribers	23	23	23
Totals	936	1,020	1,115

The continued increase of the membership is a matter of congratulation, and the Council trust that the members will, at all times, endeavour to extend the membership. The formation of the class of Associates, consisting of persons occupying subordinate positions in mining, has proved very successful, and, together with the Students, has materially increased the roll of members.

The members have to regret the death of Mr. William Armstrong, one of the original members of the Institute and a Vice-President, who had been actively connected with the Institute from its commencement in 1852.

The thanks of the members have been accorded to Messrs. W. C. and G. R. Cockburn for presenting an oil-painting of the late Mr. Nicholas Wood, the first President of the Institute.

The following alterations of Bye-laws 13 and 17 were adopted at a Special General Meeting of the members, and have been approved by the Secretary of State for the Home Department :—

13.—The *Transactions* of the Institute shall not be forwarded to those whose subscriptions are in arrear on the first of November in each year.

17.—Any Member, Associate Member, Associate or Student may, at any time, compound for all future subscriptions by a payment in accordance with the following scale :—

Under 30 years of age, the sum of			£31
Over	30	,, ,,	27
,,	40	,, ,,	24
,,	50	,, ,,	21
,,	60	,, ,,	17

or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

A Departmental Committee has been appointed by the Secretary of State for the Home Department to test explosives for the purposes of the Coal Mines Regulation Act, 1896, and a government testing-station has been erected near Woolwich. It is a matter for regret that the request made by the Institute has not been acceded to, that the extensive explosives testing-plant erected at Hebburn should be maintained and used as a testing-station under government patronage.

The meetings of Students have been continued, and four papers have been printed in the *Transactions*.

It is anticipated that a meeting of members of the Western Australian branch will shortly be held in Perth for the reading and

discussion of papers; and the Council trust that Indian and Colonial members will promote the formation of similar localized branches.

The Report of the Committee on Mechanical Ventilators is completed, and will be issued to the members during the course of the next few months.

The sixth volume of the *Sinkings and Borings* (U to Z) will shortly be completed, and members are requested to send copies of any unpublished sections of strata in Northumberland or Durham to the Secretary, with the view of their being published in a supplementary volume.

A General Index to Volumes I. to XXXVIII. of the *Transactions* of the Institute is in preparation, and the Council trust that it will be received with approval by the Members.

The additions to the Library by donations, exchanges, purchase, etc., have been:—

Bound volumes	275
Pamphlets, reports, etc.	243
A total of	518 titles.

The Library now contains 7,453 volumes and 1,504 unbound pamphlets, etc. The card catalogue is completed, and the books are now readily accessible to the members. The Library (including the books and numerous technical newspapers) is open from 10 a.m. to 5 p.m., and members residing at a distance may make use of the books, on payment of carriage, by application to the Secretary. Some of the files of publications have been rendered incomplete by the neglect of members to return books to the Library, and it is urgently requested that they search for and return the missing volumes.

By mutual arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne, the doorway between the adjacent libraries is opened daily, and the members of either society are allowed (on the production of a member's pass) to refer to the books in the library of the other society.

The Library would be rendered more valuable if members would present volumes, etc., which they can spare from their own libraries, and they would also render valuable service to the profession by bequeathing books, reports, plans, etc., to the Library, where they would be preserved, be available for reference, and perpetuate the memory of the donor. The Watson collection of mining plans, reports, etc., has proved most valuable for purposes of reference.

The prices of the *Transactions* and other publications have been con-

siderably reduced, and members are recommended to complete their sets before the stock is exhausted (some of the volumes being already sold out).

Mr. W. Hamilton Merritt has been appointed to represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science, to be held in Toronto, Canada, in August, 1897. Mr. John Daglish acts on behalf of the Institute as a governor of the Durham College of Science, Newcastle-upon-Tyne. Mr. W. Cochrane is the Institute representative on the Science and Art Committee, and Mr. J. L. Hedley on the Scholarships Committee of the Northumberland County Council.

The Federated Institution of Mining Engineers has now completed its eighth year, during which general meetings have been held in South Wales on September 15th, 16th, and 17th, 1896; in Lancashire on February 17th, 18th, and 19th, 1897; and in London on June 3rd, 4th, and 5th, 1897. An excursion meeting was held in Belgium, on June 7th, 8th, 9th, and 10th, when the members visited some of the principal collieries and works. A meeting of students and junior members was held in Yorkshire on August 5th, 6th, and 7th, 1896. The success that has attended the working of The Federated Institution of Mining Engineers would be more completely assured, if it embraced all the societies interested in mining, metallurgy, and their allied industries. The Council therefore urge members, who may be interested in other societies, to use their influence in favour of federation. Apart from other advantages, each member of one of the six federated societies receives, yearly, two volumes of *Transactions*, comprising some 70 or 80 papers and upwards of 150 notes of papers on subjects of general and special interest.

The late President's (Mr. Thomas Douglas) students' prize was awarded to Messrs. W. R. Bell and E. McGowan for their paper on "Haulage at Wearmouth Colliery."

Prizes of books have been awarded to the writers of the following papers, communicated to the members during the year 1895-96:—

"Coal-cutting by Machinery." By Mr. Wm. Blakemore.
"The Resistances of Air-currents in Mines." By Mr. T. L. Elwen.
"A Compound Winding-engine." By Mr. William Galloway.
"The Quicksilver Mines and Reduction-works at Huitzuco, Guerrerro, Mexico." By Mr. Edward Halse.
"The Whitehaven Sandstone Series." By Mr. J. D. Kendall.
"Notes on the Geological Features of the Coast of North Wales from Liverpool to Menai Bridge." By Mr. C. E. de Rance.
"The Mode of Obtaining a True North Line." By Mr. A. L. Steavenson.
"Safety Explosives." By Bergassessor Winkhaus.

The papers communicated to the members during the year have been as follows:—

"Shaw Gas-tester." By Dr. P. P. Bedson.
"Notes upon Gold-mining in Burma." By Mr. A. H. Bromly.
"Eccentric Haulage-clip." By Mr. John Brown.*
"Notes on the Venterskroom Gold-fields, South African Republic." By Mr. H. B. Bunkell.
"The Gold-fields of the Hauraki Peninsula, New Zealand." By the Rev. Joseph Campbell.
"Cornish Methods of Mine-timbering." By Mr. G. P. Chaplin.*
"The Mineral Resources of the Colony of Queensland." By Mr. William Fryar.
"Notes on the Coal-seams of the Transvaal, and Description of a Modern Pit-head Plant." By Mr. W. T. Hallimond.
"The Coal-industry of the South-eastern States of North America." By Mr. Jeremiah Head.
"A Spring-coupling for Winding or Hauling-ropes." By Mr. H. W. Hollis.
"Notes upon Foreign Mining Laws and Adequate Areas for Mining Concessions." By Mr. H. D. Hoskold.
"Honigmann System of Boring and Sinking Shafts." By Mr. Th. Lichtenberger.
"Note on the Tellurium Mineral of Choukpazat, Burma." By Prof. Henry Louis.
"Notes on Coal-mining." By Messrs. Algernon Noble and Norman Nisbet.*
"Economical Combustion of Coal for Steam-raising Purposes." By Mr. T. E. Parrington.*
"The Education of Metallurgists." By Mr. Saville Shaw.
"Notes on the Sinking of Two Shafts at Claravale Colliery, near Wylam-upon-Tyne." By Mr. Frank R. Simpson.
"Further Experiments with Explosives." By Bergassessor Winkhaus.
"The Danger of Employing Safety-fuzes for Blasting in Fiery Mines." By Bergassessor Winkhaus.

In conclusion, the Council urge the members to use their best endeavours to increase the membership, as the continued success of the Institute will depend upon its ability to pay the expenses of committees appointed to carry out investigations on questions of interest to the professions of mining or mechanical engineering, and to meet the considerable expenses incurred by the connexion of the Institute with The Federated Institution of Mining Engineers.

Mr. J. B. Simpson, in moving the adoption of the report, said that it was satisfactory to find that during the past two years the membership had largely increased, and that they had now a greater number of members than at any time since the formation of the Institute.

* Student's paper.

Another interesting feature of the report referred to the facilities afforded to the members by their valuable library, which was one of the best mining libraries in the world.

Mr. W. S. Harris seconded the resolution, which was unanimously adopted.

The Treasurer read the Report of the Finance Committee as follows:—

REPORT OF THE FINANCE COMMITTEE.

The total income for the year amounted to £2,423 2s. 4d.; deducting from this the sum of £155, compositions in lieu of annual subscriptions; £49 7s. 0d., subscriptions paid in advance; and £16 0s. 4d. received from The Midland Institute of Mining, Civil, and Mechanical Engineers as their moiety of the expenses of the Fan Ventilation Committee; the sum of £2,202 15s. 0d. remains as the ordinary income of the year, compared with £2,154 15s. 9d. for the previous year—an increase of £47 19s. 3d.

In accordance with the decision of the Council, the names of several members whose subscriptions were in arrear, have been struck out of the list of members. The amounts written off in consequence are:—For current year, £38 17s. 0d.; and arrears, £32 11s. 0d. The amount of subscriptions now in arrear, in excess of one year, is £53 11s. 0d.

The total expenditure amounted to £2,056 2s. 11d., a decrease of £179 9s. 1d. The principal items accounting for this decrease are the closing of the expenditure of the Explosives Committee, and a decrease in the amount paid for printing and stationery.

The contributions to The Federated Institution of Mining Engineers, amounted to £999 18s. 6d., an increase of £106 4s. 8d., due to the increased number of members.

During the year the sum of £200 was placed on deposit account with the bankers, and it is proposed that a further sum of £250 be similarly deposited pending the selection of a suitable investment.

The Chairman moved the adoption of the report, and this being seconded by Mr. J. B. Simpson, was unanimously adopted.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

FOR THE YEAR ENDING

	£ s. d.	£ s. d.
July 28th, 1896.		
To Balance at Bankers	575 17 8	
„ „ in Treasurer's hands	83 7 1	
„ Outstanding Amounts due for Authors' Excerpts ...	4 13 9	
July 31st, 1897.		663 18 6
To Dividend of 7½ per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for year ending June, 1897	219 0 0	
„ Interest on Mortgage of £1,400 with Institute and Coal Trade Chambers Company, Ltd.	49 0 0	
		268 0 0
„ Midland Institute of Mining, Civil, and Mechanical Engineers, Fan Committee Expenses		16 0 4
„ Sales of Publications		14 6 0
To SUBSCRIPTIONS FOR 1896-97 AS FOLLOWS:—		
608 Members ... ... @ £2 2s.	1,276 16 0	
55 Associate Members ... ... @ £2 2s.	115 10 0	
70 Associates ... ... @ £1 1s.	73 10 0	
31 Students ... ... @ £1 1s.	32 11 0	
81 New Members ... ... @ £2 2s.	170 2 0	
36 New Associate Members ... ... @ £2 2s.	75 12 0	
9 New Associates ... ... @ £1 1s.	9 9 0	
8 New Students ... ... @ £1 1s.	8 8 0	
	1,761 18 0	
To SUBSCRIBING FIRMS, VIZ.:— £ s. d.		
11 @ £2 2s.	23 2 0	
6 @ £4 4s.	25 4 0	
2 @ £6 6s.	12 12 0	
3 @ £10 10s.	31 10 0	
	92 8 0	
To Subscriptions in Suspense...	12 12 0	
	1,866 18 0	
To 7 Members' Life Compositions	155 0 0	
	2,021 18 0	
Less—Subscriptions for current year paid in advance at the end of last year...	126 0 0	
	1,895 18 0	
Add Arrears received	179 11 0	
	2,075 9 0	
Add Subscriptions paid in advance during current year	49 7 0	
		2,124 16 0
		£3.087 0 10

INSTITUTE OF MINING AND MECHANICAL ENGINEERS CR.

JULY 31ST, 1897.

July 31st, 1897.	£	s.	d.	£	s.	d.
By Printing and Stationery				195	1	4
„ Books for Library	45	17	11			
„ Prizes for Papers	16	16	0			
„ Incidental Expenses	52	13	10			
„ Postages	62	0	0			
„ Sundry Accounts	8	18	7			
„ Travelling Expenses	0	3	0			
„ Salaries	150	0	0			
„ Clerks' Wages	197	12	4			
„ Reporter's Salary	12	12	0			
„ Rent	99	15	0			
„ Rates and Taxes	18	15	5			
„ Insurance	9	7	4			
„ Furnishing and Repairs	73	4	11			
„ Coals, Gas, Electric Light, and Water	45	13	8			
„ Translations of Papers	4	15	0			
„ Library Card Catalogue	26	13	8			
„ Expenses of Meetings	25	10	2			
				850	8	10
By Explosives Committee	1	14	3			
„ Fan Committee	2	0	0			
„ British Association Meeting—Delegate's Expenses ...	7	0	0			
				10	14	3
By The Federated Institution of Mining Engineers—						
Subscriptions	1,017	10	5			
Less—Amounts paid by Authors for Excerpts ...	17	11	11			
				999	18	6
				2,056	2	11
By Investments—						
Lambton & Co. Deposit Account				200	0	0
				2,256	2	11
By Balance at Bankers	725	10	6			
„ „ in Treasurer's hands	100	0	0			
Outstanding Amounts due for Authors' Excerpts ...	5	7	5			
				830	17	11
				£3.087	0	10

I have examined the above account with the books and vouchers relating thereto, and certify that, in my opinion, it is correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 6th, 1897.

DR. THE TREASURER IN ACCOUNT

			£ s. d.	£ s. d.
To 767 Members.				
34 of whom are Life Members.				
733	733	@ £2 2s.		1,539 6 0
To 78 Associate Members,				
6 of whom are Life Members.				
72	72	@ £2 2s.		151 4 0
To 83 Associates		@ £1 1s.		87 3 0
To 46 Students		@ £1 1s.		48 6 0
To 23 Subscribing Collieries				96 12 0
To 7 New Members, paid Life Composition				155 0 0
To 81 New Members		@ £2 2s.		170 2 0
To 36 New Associate Members		@ £2 2s.		75 12 0
To 9 New Associates		@ £1 1s.		9 9 0
To 8 New Students		@ £1 1s.		8 8 0
To Subscriptions in Suspense				12 12 0
				2,353 14 0
To Arrears, as per Balance Sheet 1895-96			253 1 0	
Less—Amount transferred from Suspense			2 2 0	
			250 19 0	
Add—Arrears considered irrecoverable, but since received			14 14 0	
			265 13 0	
Less—Struck off as irrecoverable—Arrears		£32 11 0		
„ „ „		Current year 38 17 0		
			71 8 0	
				194 5 0
				2,547 19 0
To Subscriptions Paid in Advance				49 7 0
				£2,597 6 0

WITH SUBSCRIPTIONS, 1896-97. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 608 Members, paid	@ £2 2s.	1,276 16 0	.....
By 118 „ unpaid	@ £2 2s.	.....	247 16 0
By 7 „ dead	@ £2 2s.	.....	14 14 0
733			
By 55 Associate Members, paid	@ £2 2s.	115 10 0	.....
By 16 „ „ unpaid	@ £2 2s.	.....	33 12 0
By 1 „ „ dead	@ £2 2s.	.....	2 2 0
72			
By 70 Associates, paid	@ £1 1s.	73 10 0	.....
By 12 „ unpaid	@ £1 1s.	.....	12 12 0
By 1 „ paid as Member		.....	1 1 0
83			
By 31 Students, paid	@ £1 1s.	32 11 0	.....
By 14 „ unpaid	@ £1 1s.	.....	14 14 0
By 1 „ dead	@ £1 1s.	.....	1 1 0
46			
By 22 Subscribing Collieries, paid		92 8 0	.....
By 1 „ „ unpaid		.....	4 4 0
23			
By 7 New Members, paid Life Composition		155 0 0	.....
By 81 New Members, paid	@ £2 2s.	170 2 0	.....
By 36 New Associate Members, paid ...	@ £2 2s.	75 12 0	.....
By 9 New Associates, paid	@ £1 1s.	9 9 0	.....
By 8 New Students, paid	@ £1 1s.	8 8 0	.....
By Subscriptions in Suspense		12 12 0	.....
		2,021 18 0	331 16 0
Less—Struck off as irrecoverable		.....	38 17 0
			292 19 0
By Arrears		179 11 0	53 11 0
By Subscriptions paid in advance		49 7 0	.....
		2,250 16 0	346 10 0
			2,250 16 0
			£2,597 6 0

Liabilities.

	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	49	7	0			
„ carried over from previous year	2	2	0			
				51	9	0
Capital				8,769	13	1
				£8,821	2	1

I have examined the above account with the books and vouchers relating thereto, and certify that, in my opinion, it is correct. The Share Certificates and Mortgage Bonds have been produced to me.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
August 6th, 1897.

Assets.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	725	10	6			
„ in Treasurer's hands	100	0	0			
Outstanding amounts due for Authors' Excerpts	5	7	5			
				830	17	11
Proportion of Fan Committee Expenses— South Wales Institute of Engineers ...	.....			34	6	8
Arrears of Subscriptions	.....			346	10	0
146 Shares in the Institute and Coal Trade Chambers Co., Ltd. (at cost)	3,130	0	0			
Investment with the Institute and Coal Trade Chambers Co., Ltd. (Mortgage)	1,400	0	0			
				4,530	0	0
(Of the above amount, £350 is due to Life Subscriptions Account, leaving £210 12s. not invested.)						
Deposit with Lambton & Co.	.....			200	0	0
Value of Transactions and other Publications, as per Stock Account	.....			679	7	6
Office Furniture and Fittings	450	0	0			
Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£8,821	2	1

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The CHAIRMAN moved, and Mr. JOHN SIMPSON seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Federated Institution of Mining Engineers:—

Mr. HENRY ARMSTRONG.
Mr. WM. ARMSTRONG.
Mr. HENRY AYTON.
Mr. R. DONALD BAIN.
Mr. JOHN BATEY.
Sir LOWTHIAN BELL, Bart.
Mr. T. FORSTER BROWN.
Mr. W. COCHRANE.
Mr. E. W. CRONE.
Mr. J. DAGLISH.
Mr. T. DOUGLAS.
Mr. G. B. FORSTER.
Mr. T. E. FORSTER.
Mr. W. GALLOWAY.
Mr. J. GERRARD.
Mr. W. F. HALL.
Mr. J. HEAD.
Mr. J. L. HEDLEY.
Mr. A. C. KAYLL.
Mr. HENRY LOUIS.
Mr. JAMES MCMURTRIE.
Mr. G. MAY.
Mr. J. MORISON.
Mr. H. PALMER.
Mr. M. W. PARRINGTON.
Mr. F. R. SIMPSON.
Mr. J. B. SIMPSON.
Mr. A. L. STEAVENSON.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WILLIAM ABRAHAMS, Government Inspector of Mines (Victoria), Bendigo, Victoria, Australia.

Mr. JAMES MAYNE CRAZE, Mining Engineer, Coolgardie, Western Australia.

Mr. HOWARD HARRIS, Mechanical and Mining Engineer, Tyne Valley Colliery, Springs, Transvaal.

Mr. GEORGE FREDERICK LABRAM, Chief Engineer, De Beers Consolidated Mines, Limited, Kimberley, South Africa.

Mr. THOMAS HAIGHT LEGGETT, Consulting Mining Engineer, P.O. Box 485, Johannesburg, Transvaal.

Mr. JOHN MORGAN, Mine Manager, Norseman Gold-mining Company, Limited, Norseman, Western Australia.

Mr. WILLIAM PILE, Consulting and Mechanical Engineer, P.O. Box 1,093, Johannesburg, Transvaal.

Mr. ROBERT THOMAS REES, Mining Engineer, Glandare, Aberdare.

Mr. ANDREW ROBERTSON, Consulting Mining Engineer, 49, Mining Exchange, Ballarat, Victoria.

Mr. ARTHUR THOMAS, Mining Engineer, Mina El Carmen, El Oro, Tultenango, Mexico.

ASSOCIATE MEMBERS —

Mr. ALBERT MONTAGUE ARMSTRONG, 3 and 4, Crooked Lane, King William Street, London, E.C.

Mr. A. CROSBY, Kroomfontein Coal Company, Limited, Brugspruit, District Middelburg, Transvaal.

Mr. C. GORDON RICHARDSON, c/o Messrs. Geo. Wm. Ballou & Company, 10, Wall Street, New York, U.S.A.

Mr. L. W. TATUM, c/o Messrs. Dwight, Furness & Company, San Luis de la Paz, State of Guanajuato, Mexico.

Mr. WILLIAM W. VAN NESS, Buluwayo, Matabeleland, South Africa.

ASSOCIATE —

Mr. FOSTER STEPHENSON, Coal-hewer, Double Row, Seaton Delaval, Northumberland.

STUDENT—

Mr. FRANK DOUGLAS MURRAY, Mining Student, 29, Albemarle Street, London; and Wardley Hall, near Newcastle-upon-Tyne.

The SECRETARY read the following paper, by Mr. Frank Reed, Inspector of Mines, on the "Hydrothermal Gold-deposits at Peak Hill, Western Australia":—

HYDROTHERMAL GOLD-DEPOSITS AT PEAK HILL, WESTERN AUSTRALIA.

By FRANK REED, Inspector of Mines, Western Australia.

The Peak Hill mines are situated between the Murchison and Gascoyne rivers, about 90 miles due north-north-east of Nannine, in latitude 25° 38′ S., and are approached by a good coach-road from Nannine *via* Mount Vranizan, Abbotts, and Mount Fraser.

Geological History.—An inspection of the geological map (Fig. 1, Plate II.) will indicate the geological formations which occur on the Peak Hill gold-field.

On the road to Peak Hill, the outcrops consist of Archæan rocks, gneiss, and granite, the basis or skeleton of the whole colony; diorite in massive or banded form (dioritic schists) the country-rock of West Australian gold; and the writer frequently found the beds of rivers and creeks lined with Neogene ferruginous sandstone.

The mines at Peak Hill are situated on a flat, in area about 160 acres (Fig. 2, Plate II.), at the foot of a small diorite hill, from which the place takes its name.

The middle of this flat is covered by a bed of auriferous cement, frequently containing small angular quartz-fragments in a ferruginous matrix, with horizontal laminations; this cement contains gold both in a disseminated form as well as in nuggets or "slugs," the largest of these yet discovered weighing about 90 ounces. The cement covers an area of about 20 acres, and has an average thickness of 4 feet.

In this cement-bed a number of large holes occur of inverted bell-shape, evidently extinct thermal craters: these vary in size up to 20 feet in diameter and 15 feet in depth; the holes are now mostly filled with loose subaërial or alluvial deposits (Fig. 3, Plate II.). The craters pass through the cement-beds into the strata beneath, consisting of decomposed and altered dioritic schists, in places containing auriferous quartz-veins, which veins pass upwards through the cement-beds and outcrop at the surface.

In the vicinity of these quartz-veins or leaders, the dioritic schists underlying the cement-beds have become entirely altered by hydrothermal or fumarole action, evidently a sequence of volcanic activity, during which the dioritic country-rock has become fractured, and deep-seated hydrothermal waters existing at high-pressure, and charged with alkaline, calcic, or magnesic carbonates, and holding gold in solution, have used the fractured parts of the rocks as a passage along the lines of least resistance to the surface.

The lines of fracture which have served as vents or conduits are now cemented and filled with hæmatite-stained quartz, and are often phenomenally rich in gold. The quartz-veins taken separately are not regular in course or inclination, but taken as a whole, several veins often occurring in close proximity, they appear much more regular and the angle of inclination appears to increase as depth is attained.

The quartz-veins frequently terminate at the extinct craters previously referred to, showing that the craters have formed the orifices or outlets for the thermal solutions.

In the immediate locality of the quartz-veins, the dioritic schist has become entirely kaolinized by the hydrothermal and fumarole action, and the solutions have penetrated into the kaolin and precipitated gold in the same, that nearest the vein receiving the greater proportion of gold.

Immediately adjacent to the veins or vents, the kaolinized rock is white in colour, and this changes to yellow and afterwards to a bluish grey before eventually assuming its dioritic schistose character at that point where the influence of the thermal solutions and fumarole effects have not penetrated.

State of Mining.—Although gold was first discovered on the Peak Hill gold-field in 1892, it is only within the past 2 years that other than surface-mining has been conducted.

The area at present being worked at Peak Hill "patch" (as the hydrothermal auriferous deposits previously referred to are termed locally) is about 130 acres, comprised in 18 leases.

The workings at the date of the writer's last visit of inspection on March 14th, 1897, had not in any instance exceeded 90 feet in depth, and as the water-level is not reached until a depth of 230 feet, the owners of the leases have plenty of "backs" to work before pumping operations will become necessary.

Owing to the remarkable richness of the ground, the owners, who generally consist of three or four working "mates," mine the ground

themselves, working out only the richest of the formation of quartz-veins and kaolin, and ore which would pay any company to work is left behind. The results of their crushings of the mined ore are phenomenal, as will be seen upon inspection of the battery returns.

Battery Returns.—The following table of battery returns includes every crushing which has taken place up to March 14th, 1897, at the Peak Hill public battery, the only crushing-plant on this gold-field.

The material is only treated by battery-amalgamation, and owing to the quantity of slimes produced from the kaolin, a considerable amount of gold, varying between 1 and 3 ounces per ton of ore crushed, is lost in the tailings. Owing to the absence of sulphides, the Peak Hill ore is eminently adapted for the cyanide process of gold-extraction, which would save the above-named loss in the tailings.

RETURN OF ORE CRUSHED FROM ALL MINES IN THE PEAK HILL GOLD-FIELD TO MARCH 14TH, 1897.

Name of Mine.	Area of Lease.	Quantity of Ore Crushed.	Yield of Smelted Gold.	Average Yield of Gold per Ton.	Description of Ore Crushed.
	Acres.	Tons	Ozs. Dwts.	Ounces.	
No. 1 North ...	6	128	497 8	3·89	Quartz & kaolin.
Atlantic ...	6	121	495 9	4·09	,, ,,
Bobby Dazzler...	6	106	333 0	3·14	,, ,,
North Star ...	6	178½	707 0	3·96	,, ,,
Peak Hill Reef	9	331	2,621 16	7·92	,, ,,
Daisy Bell ...	—	133	1,788 17	13 45	,, ,,
Golden Chimes	—	195	1,402 9	7·14	,, ,,
Commercial ...	6	70	551 0	7·87	,, ,,
Evening Star ...	6	61¼	66 0	1·04	,, ,,
Reward Claim...	—	725	885 9	1·22	Cement.
,, ,, ...		not known	(3,766 0)	—	—
Totals ...	—	2,048¾	9,348 8	4·56	—

NOTE.—The value of the smelted gold from Peak Hill mine is always above £4 per ounce, and has reached £4 1s. 6d.

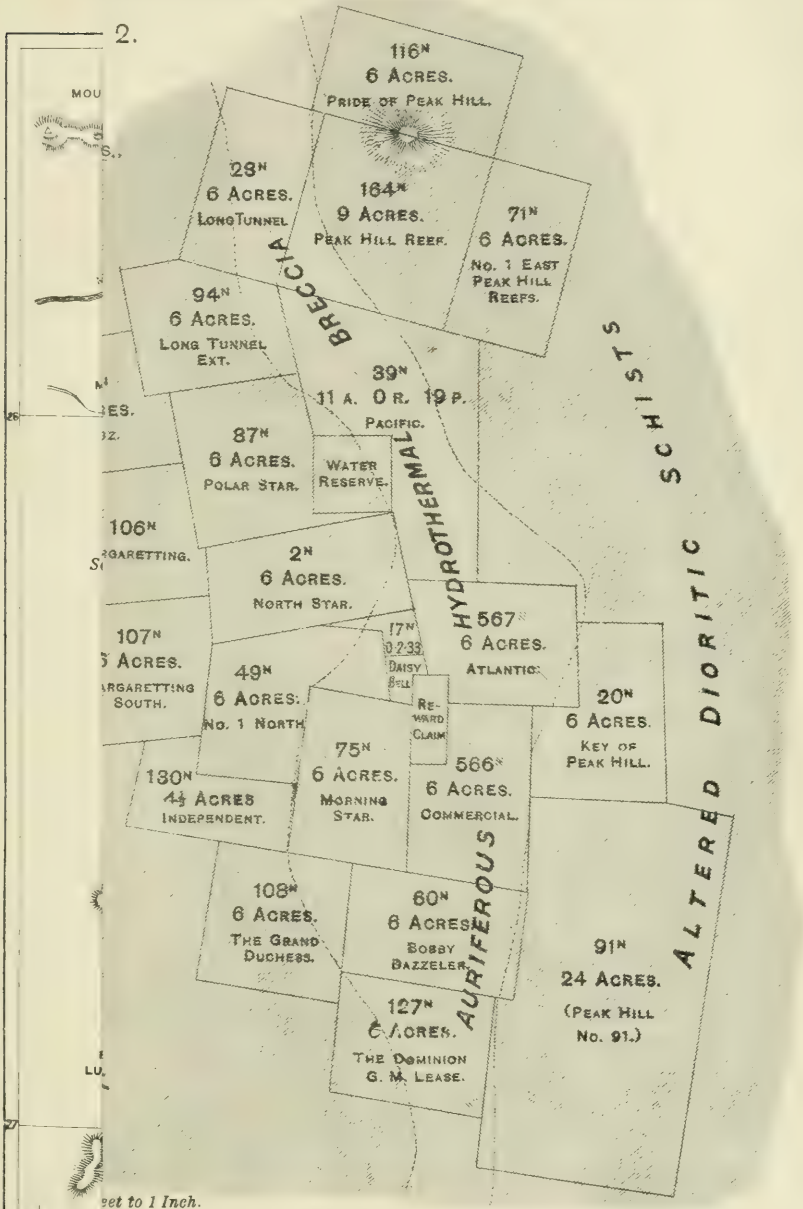
Although mining operations at Peak Hill have not exceeded a depth of 90 feet, the writer is of opinion that owing to the deep-seated origin of the auriferous thermal solutions and the fissures or vents which have once served as their conduits, it is reasonable to conclude that the decomposing influence of the former has acted in a similar manner at lower levels on the dioritic schists, and that at least as much gold has been precipitated in the kaolinized rocks and the fissures in the lower ground as is now found comparatively near the surface. The writer, consequently, believes that the auriferous formation will exist to a considerable depth and that

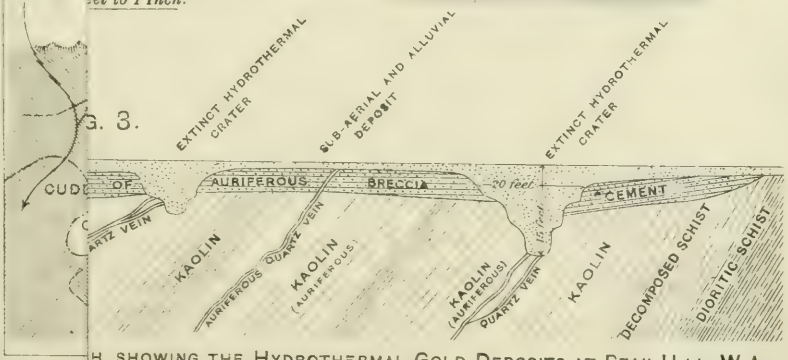
the mass of auriferous quartz-veins will tend to concentrate and assume a more lode-like form with a greater degree of inclination at lower levels, which tendency the writer has already observed in the lower workings of two of the mines.

In connexion with the dioritic schist-rock, which is a characteristic of the Western Australian gold-fields, the writer may state that this formation originally consisted of massive diorite or diabase, but by tangential dynamic pressure it has assumed a schistose form. These dioritic schists occur as breaks in the Archæan gneiss and granite, and form the country-rock of the Western Australian gold-fields.

The CHAIRMAN moved a vote of thanks to Mr. Reed for his interesting paper, and the motion was cordially approved.

The SECRETARY read the following paper, by Mr. Wm. B. Phillips, on "The Gold Regions of Alabama, U.S.A.":—





H, SHOWING THE HYDROTHERMAL GOLD DEPOSITS AT PEAK HILL W.A.

GEOLOGICAL MAP SHOWING PEAK HILL DISTRICT, W.A.

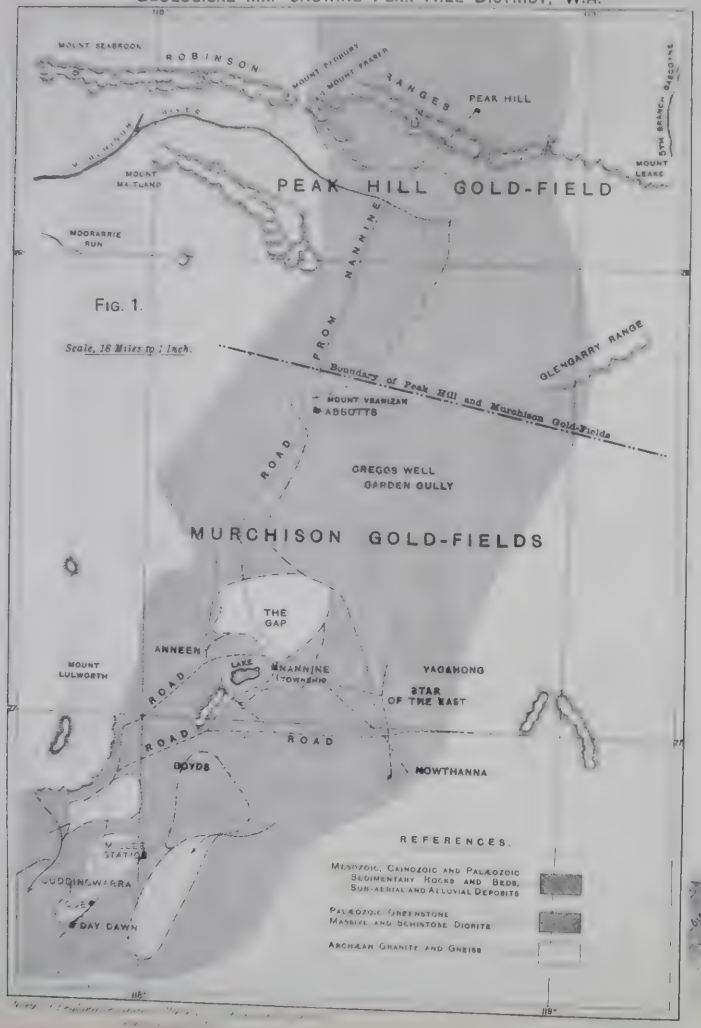


FIG. 1.

FIG. 2.

PLAN OF PEAK HILL GOLD MINING LEASE ... W.A.

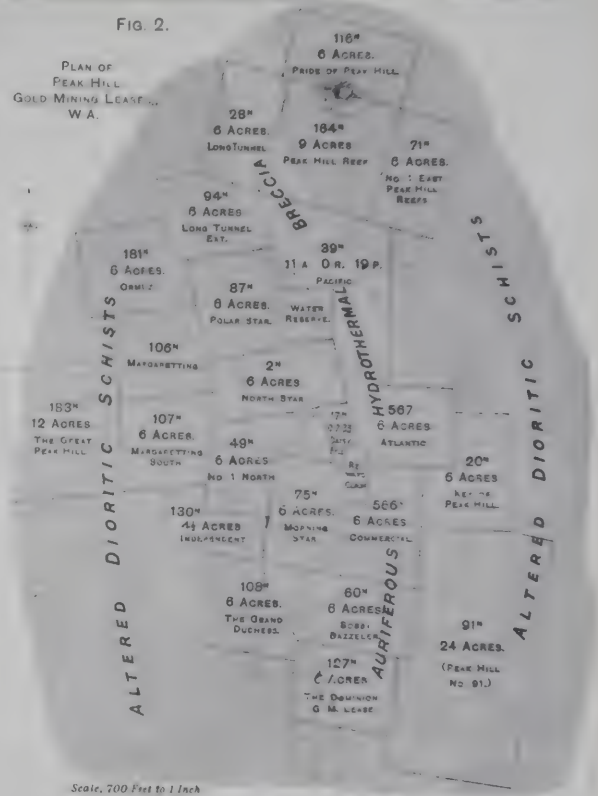
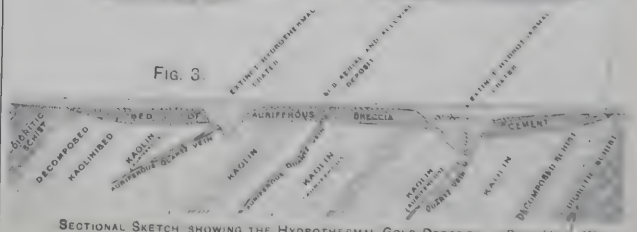

116M 6 ACRES. PRIDE OF PEAK HILL
28M 6 ACRES. LONG TUNNEL
164M 9 ACRES PEAK HILL REEF
71M 6 ACRES. No 1 EAST PEAK HILL REEFS
94M 6 ACRES LONG TUNNEL EXT.
BRECCIA
39M 11 A. 0 R. 19 P. PACIFIC
181M 6 ACRES. ORMILE
87M 6 ACRES. POLAR STAR.
WATER RESERVE.
106M MARGARETTING
2M 6 ACRES NORTH STAR
ALTERED DIORITIC SCHISTS
HYDROTHERMAL
AURIFEROUS
SCHISTS
ALTERED DIORITIC
183M 12 ACRES THE GREAT PEAK HILL
107M 6 ACRES. MARGARETTING SOUTH
49M 6 ACRES No 1 NORTH
567 6 ACRES ATLANTIC
20M 6 ACRES
75M 6 ACRES. MORNING STAR
130M 44 ACRES INDEPENDENT
566M 6 ACRES COMMERCIAL
109M 6 ACRES. THE GRAND DUCHESS.
60M 6 ACRES
91M 24 ACRES. (PEAK HILL No. 91.)
127M 6 ACRES THE DOMINION G. M. LEASE
Scale, 700 Feet to 1 Inch

FIG. 3.



SECTIONAL SKETCH SHOWING THE HYDROTHERMAL GOLD DEPOSITS AT PEAK HILL W.A.

THE GOLD REGIONS OF ALABAMA, U.S.A.

By WM. B. PHILLIPS.

Since the admission of Alabama into the Union, as a state, in 1819, there has been more or less interest exhibited in the possibility of working the gold-deposits profitably. In the early days, from 1830 to 1850, a very considerable amount of work was done, the culminating period being between 1845 and 1855.

Immediately prior to the California gold-fever, in 1849, there were some 5,000 men employed in the counties of Chilton, Coosa, Tallapoosa, Clay, and Cleburne, the town of Arbacoochee, in Cleburne county, alone having a tributary population of 2,000 to 3,000. Those were the days of the crudest sort of stamp-mills, of sluice-boxes, long-toms, and cradles. It is more than probable that the stamp-mill, as applied to gold-ores, had its origin in the northern part of Georgia, near Dahlonega, a district some 200 miles north-east, as the crow flies, from the Alabama gold-regions. It was not a Californian invention, although the irony of history has long since obscured the fame of the Georgian inventor.

The ores treated were the placer-gravels and the upper portion of the quartz-reefs, the one for nugget-gold, the other for the gold equally free but in a finer state of division. No large nuggets have ever been found in the state of Alabama, the largest being valued at £50 ($240), and coming from the Arbacoochee placer in Cleburne county, now practically exhausted. The workings on the quartz-reefs seldom exceeded 40 feet in depth, and were discontinued when the harder rock was struck at water-level, and when sulphide ores began to appear.

According to Dr. Eugene A. Smith, state geologist,* the total area of the crystalline rocks in Alabama is 4,425 square miles, but in a report to the Geological Survey, in 1891-92, the writer estimated the productive area at about 3,500 square miles, and it is likely, so far as concerns the profitable working of the gold-ores, that this estimate will have to be diminished by one-half. The area covered by the crystalline rocks, whether of pre-Silurian or Silurian age, lies in the eastern part of the state, south of a line drawn from Atlanta, Georgia, to Birmingham, and

* *Agricultural Report* for 1881-2.

east of a line drawn from Birmingham to Columbus, Georgia. Roughly speaking, it forms a triangle of 90 miles to each side. Within this area, occur granites, gneisses, crystalline schists, and marbles. It forms in reality the south-eastern prolongation of the Appalachian Mountains, which extend, almost without a break, along the Atlantic slope of the United States, from the northern boundary of New Hampshire to the middle of Alabama, a distance of 1,500 miles. The highest peak along this range is Mitchell's High Peak, in the western part of North Carolina, which rises to an elevation of 6,688 feet. From that point towards the south-east, the peaks gradually decrease in height until in Alabama the height is but 2,400 feet in Mount Chewacla, Clay county.

Disregarding the placers, which really do not cut much of a figure, the gold-ores of Alabama are of two kinds, quartz-reefs and decomposed schist, or gneiss, the so-called "saprolite" of Dr. Becker (a term applied to decomposed rock *in situ*).

The quartz-reefs do not differ essentially from such occurrences elsewhere along the Atlantic slope, in Virginia, North and South Carolina, and Georgia. In Alabama, the prevailing strike is about 25 degrees north of east, with a south-easterly dip, varying from 25 to 40 degrees. They are held in the ordinary country-rock, be it slate or schist, carry free-gold in the upper levels, with little or no sulphide ores, and pass gradually into sulphide ores below water-level. Practically all of the gold in the upper levels is free, but when the undecomposed ore is struck, the ratio of the free-gold to that held in the sulphide ores is about as 1 to 3, *i.e.*, a sulphide ore carrying 37s. 6d. ($9) per ton will have about 12s. 6d. ($3) per ton of free-gold. This, however, is true only in a general way, and cannot be asserted as to all sulphide ores.

In places, the quartz carries 3 to 4 ounces of gold to the ton, and in rare cases, as in a shallow pit near Arbacoochee, Cleburne county, a value of £416 ($2,000) per ton has been recorded. But these instances are extremely rare, and experience has shown that such rich ore cannot by any means be depended upon. It is very doubtful whether any quartz-reef in the state will yield as much as $\frac{1}{2}$ ounce per ton on regular operations, and the average will be closer to $\frac{1}{3}$ than to $\frac{1}{2}$ ounce. The fact that gold-mining in the modern sense of the term does not now exist in Alabama, the operations being confined to two or three mills, prevents one from saying much about the matter. There is not a mine in the state that is worked to a depth of 100 feet, so that assays of the ore taken from the upper parts of the reefs cannot be said to represent

the ore proper. The decomposed part of the ore is soon exhausted, and with it the part that gives the best assays and that lends itself readily to ordinary amalgamation. What deep mining will reveal no one can assert, but if the rule which holds good on similar ore elsewhere will apply here, certainly the free-milling ore will give place to sulphide ores below water-level. Then it becomes a question of concentration and chlorination, for the free-gold alone will not pay expenses.

This much, however, may be said, that there are many quartz-reefs practically untouched that carry from 16s. 8d. to 25s. ($4 to $6) a ton regularly, and some contain stringers and chimneys of much greater value. These reefs to depths of 40 to 60 feet are composed of friable quartz, easily crushed, and all of the gold is free. A 25s. ($6) free-milling ore is not to be despised, and from considerations of climate, labour, timber, and fuel, it is believed that a 16s. 8d. ($4) ore can be profitably worked. Ordinary labour is paid 3s. 1½d. (75 cents) a day, blacksmiths and carpenters, 6s. 3d. ($1·50), sawed lumber, 29s. 2d. ($7) per thousand feet, and cord-wood, 3s. 4d. (80 cents) per cord, delivered and stacked. Out-door work goes on every day in the year, and severe weather is unknown. Alabama has the distinction of producing the cheapest pig-iron in the world, not only because of the proximity of the raw materials to each other, but also and especially because of the cheap ore. The ore necessary for the production of 1 ton of iron can be and has been put into the stock-house for 4s. 7d. ($1·10) and it is this fact that has enabled our iron-masters to hold out in the face of long continued depression.

This state could also enter the list of gold-producers, and maintain a respectable position by means of her low-grade gold-ores. These are the decomposed schists (or gneisses) carrying from 4s. 2d. ($1) to 10s. 5d. ($2·50) a ton, which can be mined and delivered for 10d. (20 cents) a ton. They carry no sulphide ores, all of the gold is free, and for the most part coarse; flour-gold is seldom met with, although present now and then. The occurrence of this decomposed rock is so peculiar, that a brief description of a typical deposit may not be out of place. In Clay county, there are enormous beds of decomposed schist, or gneiss, that run across the county in a general north to east course, dipping towards the south-east. The underlying rock is a fine to medium-grained gneissoid schist, probably of Lower Silurian age, very tough and hard below water-level, but comparatively soft to depths of 30 and 40 feet. These beds are traversed by quartz-seams of varying thickness, from a knife edge to 30 inches, for the most part interbedded, but not infrequently cutting the schist at innumerable angles. These quartz-seams do not always

carry gold, but now and then they are worth mining, and in a few cases are fairly rich, carrying from $\frac{1}{2}$ to 1 ounce of gold per ton. The decomposed schist carries the gold, and not the quartz, although quartz is invariably present when the pan shows colours of gold. The schists may be classified under four heads :—(1) micaceous, (2) graphitic, (3) manganiferous, and (4) garnetiferous ; the classification depending on the predominance of mica, graphite, manganese stains, and iron garnets. No hard-and-fast line can be drawn between these classes of ore, as they shade into each other imperceptibly, often appearing on the same property, and to some extent in the same opening. In addition to the schists there is also found a decomposed felspar which carries free gold, the kaolinization having progressed so far as to leave the rock, near the surface at least, soft and friable, breaking easily under the hammer, and panning white. A similar occurrence, *i.e.*, partially kaolinized felspar carrying free gold, is to be seen at the Boilston mine, Henderson county, North Carolina, as noticed by the writer several years ago.

Of the four classes of ore the most striking and perhaps the most valuable is the garnet-schist, a decomposed gneissoid schist of deep red colour, and full of iron garnets, some of them as large as a man's fist. The free gold begins at the surface, the earth adhering to the roots of grass and maize, giving fine colours in the pan. The perfectly solid garnets do not seem to carry gold, but when they are partially decomposed and fissured, the exterior and the cracks being filled with deep red ochre, they are often rich. At depths so far reached, 30 to 40 feet, the garnets are plentifully sprinkled in the earth and schist, following no lines of deposition, but lying as raisins in a cake. The entire mass of soil, earth, decomposed schist in place, garnets and thin seams of quartz, to a depth of at least 35 feet, can be mined and sent to the mill. The value of the ore varies from 4s. 2d. to 10s. 5d. ($1 to $2·50) a ton, and as it can be mined and delivered to the mill for 10d. (20 cents) and milled for 1s. 3d. (30 cents), there is a fair opportunity for profitable working.

There is at present one 5 feet Huntingdon mill in successful operation, handling 20 to 25 tons per day of 24 hours, and using a decomposed manganiferous schist carrying from 4s. 2d. to 10s. 5d. ($1 to $2·50) a ton in free gold. The writer is at present putting in a 5 feet Huntingdon mill to work a mixture of micaceous and garnetiferous schist of about the same value.

The accompanying sketch-map of the gold-bearing regions of the state (Fig. 1, Plate III.) and of Clay county (Fig. 2, Plate III.) may be of some interest.

To illustrate Mr. Wm. B. Phillips's Paper on "The Gold Region of Alabama, U.S.A."

FIG. 1.

SKETCH MAP

OF

ALABAMA, U.S.A.

Scale, 90 Miles to 1 Inch.

REFERENCES.

COAL-MEASURES

CRYSTALLINE ROCKS (GOLD-BEARING)

RAILWAYS

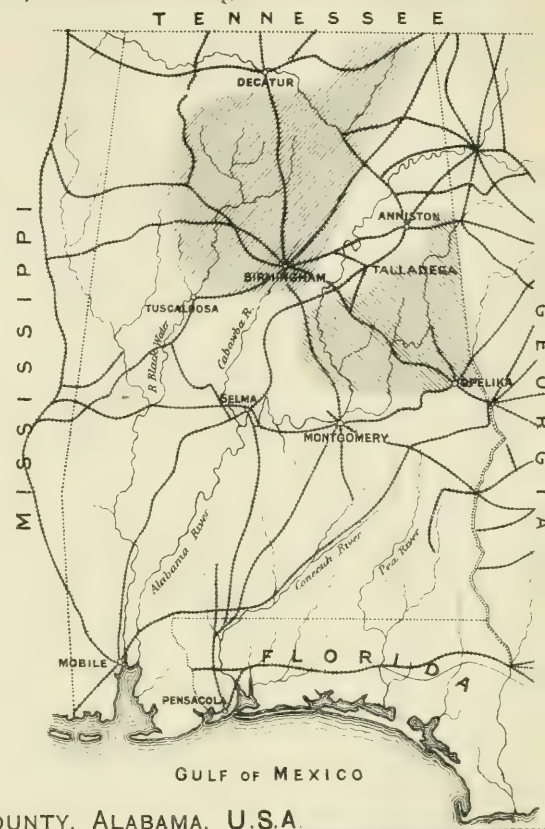


FIG. 2.

SKETCH MAP OF CLAY COUNTY, ALABAMA. U.S.A.

Scale, 6⅔ Miles to 1 Inch.

REFERENCES.

TALLADEGA SLATES (GOLD-BEARING)

CRYSTALLINE SCHISTS (GOLD-BEARING

RAILWAYS

ROADS

At present, the county suffers from lack of railway facilities, the nearest station being 10 miles away, and the road none of the best. The farming interests are somewhat backward, but the soil is fertile and well adapted for all the crops of the Southern States. Grapes, berries, and all kinds of fruits thrive excellently well. The country is hilly and well watered, and the climate is all that the most fastidious could reasonably desire.

This brief description of what promises to be a profitable gold-mining district is given with no thought of "booming" Alabama gold-mines. There are no bonanzas here, but the returns to well-ordered business management are certainly attractive.

Alabama has become known as a coal- and iron-producing state within the last 10 or 15 years, but there are not many who are aware that she could also produce gold profitably. Such, however, is the case, and it is hoped that this brief paper, which is hardly more than a note, may arouse at least professional interest in the subject.

DISCUSSION ON MR. BROMLY'S "NOTES UPON GOLD-MINING IN BURMA."*

Dr. Fritz Noetling (Calcutta) wrote that it must appear rather strange that Burma has always been noted for its mineral wealth, though in the light of recent researches, the fame thus acquired seems to be considerably exaggerated. Gold, particularly, was said to occur in large quantities, and there seems to be no doubt that the gilded pagodas scattered in countless numbers all over the country, have done much to support this view. Now, we know almost for certain that the occurrence of gold in Burma is very limited, at least as regards its occurrence in paying quantities. The frequent occurrence of the Burmese word *shwé* (= gold) in connexion with the names of villages or small streams is very deceptive, because on closer examination it will almost always be seen that in such localities gold was washed from the sand in an erratic manner during the off season.

So far, the only part of Burma where gold seems to occur in veins containing it in workable quantities is Wuntho in Central Burma. When Wuntho was finally occupied, a number of prospectors flocked to the district, prospecting licenses were issued, but although expectations ran

* *Trans. Fed. Inst.*, vol. xii., page 506.

high at the beginning, it seems that only a single concern has met with some success. He (Dr. Noetling) examined the auriferous tract early in 1893, when Choukpazat was still in its infancy, that is to say, it had not got beyond the prospecting stage yet. The dense jungle made any examination extremely difficult, and he was therefore only able to form a general idea about the occurrence of the gold. It is therefore very useful that Mr. Bromly, who knows Choukpazat from his own experience, has taken the trouble to write the above-named paper, which considerably increases our knowledge of the occurrence of gold in Burma. His own (Dr. Noetling) observations with regard to the geology have, so far, been fully confirmed. The information on the working of the ore, and on the cost of labour, which he (Dr. Noetling) could fully bear out from personal experience, form a particularly interesting feature of Mr. Bromly's paper. He (Dr. Noetling) might, however, add that Wuntho is an exceedingly feverish country, and that skilled European labour will have eventually to be paid much higher than at present, because there will be very few who will be able to stand the heat and the strain of the fever-breeding jungle.

DISCUSSION ON PROF. DE LAUNAY'S "GEOLOGICAL DESCRIPTION OF THE GOLD-MINES OF THE TRANSVAAL."*

Mr. Edward H. Clifford (Johannesburg) wrote that Prof. De Launay assumed that both the pyrites and gold were deposited at the same time as the pebbles, and that some portion of both were precipitated from solution. If this be so, why should the sandstone immediately next the reefs be almost free from both pyrites and gold in the majority of cases? And how is it that gold is not generally concentrated in the lower parts of the beds? Prof. De Launay tentatively put forward the theory of marine origin, on account of the position of the series between marine fossiliferous beds, its area, and the frequent presence of flattened pebbles. With regard to area, the gravel deposits of some Asiatic rivers already cover areas of thousands of square miles, and the marine beds lying above and below the series are both unconformable, and prove nothing in this connexion.

* *Trans. Fed. Inst.*, vol. xi., page 378; and vol. xiii., page 122.

With regard to the origin of the contents of the reefs, Prof. De Launay assumed that, so far as the silica was concerned, fragments of all kinds of rocks had been subjected to such attrition that only quartz had survived. The rolled pyrites, on the other hand, could not have travelled far, and owing to its friable nature, would have been obliterated in case of any such attrition *in situ*, as must be assumed in the case of the quartz. Prof. De Launay said that gold was never found in the pebbles except in fissures; this was incorrect, as both gold and pyrites were occasionally found in pebbles in such a way as to leave no doubt that they were already present in the original rock.

The meeting was then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 9TH, 1897.

MR. GEORGE MAY, PRESIDENT, IN THE CHAIR.

Mr. G. B. FORSTER said that since the last meeting of the Institute he regretted to announce that they had lost an old and very valued member and a past vice-President of this Institute by the death of Mr. T. J. Bewick, which took place recently. He proposed that the Secretary be instructed to write a letter of sympathy to his son, Mr. T. B. Bewick, and say how much the Institute condoled with him and regretted the loss which he as well as the members had suffered by his father's death. Mr. Bewick was a man who was well known and highly respected. He was endeared to those who knew him by his amiable and straightforward conduct, and as a professional man, his superior attainments and great capabilities enabled him to take the high position which he held as a mining engineer.

Mr. T. W. BENSON, in seconding the proposal, said that as an old friend of the late Mr. Bewick, he could thoroughly endorse every word which had fallen from Mr. Forster. Mr. T. J. Bewick had always taken the greatest possible interest in the affairs of this Institute, and until his removal to the south of England he attended all the meetings perhaps more regularly than almost any other member. The deceased gentleman might not perhaps be so well known to the younger members, but for the past 35 years he had been a valued member and always took an active interest in the affairs of the Institute, which would be a great loser by his death.

The motion was unanimously adopted.

The minutes of the last General Meeting were read, and the proceedings of the Council at their meetings on September 25th and that day

were reported, together with the proceedings of the Council of The Federated Institution of Mining Engineers on September 14th.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. WILLIAM EDWARD CAYLEY ALEXANDER, Mining Engineer, Lynton House, Hampstead Lane, Highgate, London, N.

Mr. ANDREW H. BOWMAN, Chief Mining Engineer, McClure Coke Company, Scottdale, Westmoreland County, Pennsylvania, U.S.A.

Mr. GEORGE HERBERT BROOME, Managing Engineer, The Westport Cardiff Coal Company, Limited, Seddonville, *via* Westport, New Zealand.

Mr. ERNEST JAMES COCHRANE, Electrical Engineer Electric Light Works, Coolgardie, Western Australia.

Mr. JOSEPH COOK, Jun., Mechanical Engineer, Washington Iron Works, Co. Durham.

Mr. SYDNEY FAWNS, Mining Engineer, Coolgardie, Western Australia.

Mr. CHARLES GREGORIE, Mining Engineer, Aberdare, South Wales.

Mr. EDMUND LOUIS HOPE, Mining Engineer, Dandot, Jhelum, Punjaub, India.

Mr. CHARLES WARREN BOWEN JENKINS, Mining Engineer, Venture Syndicate, Perth, Western Australia.

Mr. JOHN DYER LEWIS, H.M. Inspector of Mines, 183, Richmond Road, Roath, Cardiff.

Mr. H. W. MARTIN, Mining Engineer, Trewern, Dowlais, Glamorganshire.

Mr. THOMAS ALOYSIUS O'DONAHUE, Mining Engineer's Assistant, 35, Princess Street, Wigan.

Mr. STEPHEN ROGERS, Mining Engineer, 27, Ferris Town, Truro, Cornwall.

Mr. JOHN R. WAGNER, Mechanical Engineer and Superintendent of Tests, The Cross Creek Coal Company, Drifton, Luzerne County, Pennsylvania, U.S.A.

Mr. HENRY BLAIR WALKER, Colliery Manager, Die Rietfontein Colliery, *via* Springs, Johannesburg, Transvaal.

Mr. FREDERICK HERBERT WHALLEY, Civil and Mining Engineer, Queen Street, Auckland, New Zealand.

Mr. JAMES YOUNG, Mechanical Engineer, 19, Wentworth Place, Newcastle-upon-Tyne.

ASSOCIATE MEMBERS—

Mr. GEORGE P. CHAPLIN, 124, Breakspear's Road, Brockley, London, S.E.

Mr. BERKLY GILLESPIE DICKSON, Irura, Tolosa, Spain.

Mr. JOHN GRAHAM, Findon Cottage, near Durham.

Mr. ARTHUR HODGETTS, 100, Smith Street, Durban, Natal, South Africa.

Mr. EDWARD JOBSON, 5, Bath Terrace, Tynemouth.

Mr. WILLIAM THOMAS REES, Maesyffynon, Aberdare, South Wales.

Mr. EDWARD STEPHEN REVETT, 32, Old Jewry, London, E.C.

Mr. WILLIAM MURRAY ROBERTS, P.O. Box 42, Barberton, Transvaal.

Mr. ALBERT TUNNINGTON, Mawson's Reward Company, Dundas, Western Australia.

STUDENTS—

Mr. JOSEPH PERCIVAL HALL, Mining Student, Cornsay Colliery, Durham.
Mr. JOHN STRAKER NISBET, Mining Student, Cramlington Collieries, Northumberland.
Mr. SYDNEY RICHARDSON, Mining Student, South Pelaw Colliery, Chester-le-Street.

SUBSCRIBERS—

Messrs. JAMES JOICEY AND COMPANY, LIMITED, Newcastle-upon-Tyne.
Messrs. THE LAMBTON COLLIERIES, LIMITED, E, Queen Street, Newcastle-upon-Tyne.

DISCUSSION UPON MR. W. GALLOWAY'S PAPER ON "SECONDARY HAULAGE."*

Mr. FRANK R. SIMPSON pointed out that Mr. Galloway, in replying to the discussion on his paper, compared the cost of his secondary haulage for a distance of 581 yards with the cost of pony-putting in this district. He (Mr. Simpson) did not think that it was usual in the North of England for putting to extend so far as that. This length would be at the worst 250 yards, and he thought that the cost assumed by Mr. Galloway should be considerably lessened. He thought also that in the North of England it was almost impossible to adopt any system of secondary haulage which would reduce the cost of handling the tubs separately. It was not motive power which constituted the principal expense of pony-putting but the cost of handling the tubs separately, and that would be true of any system of face-haulage. In the case of endless-ropes, where the rope happened to be underneath the tub, there was a convenient way of extending the haulage by carrying the ropes between a single line of rails beyond the main line where the double width was made.

Mr. J. H. MERIVALE thought that Mr. Galloway was to be congratulated on having mastered so satisfactorily the particular problem in which he was interested at his own collieries, but the system was hardly applicable to the conditions existing in this district. Mr. Galloway was dealing, he thought, with a colliery where the seams were dipping in-bye 1 in 24; he was also dealing with a large tub holding something like 2 tons of coal and, as Mr. Simpson pointed out, with a distance of about 600 yards, whereas the pony-haulage in this district was usually only a matter of about 150 yards. It seemed to him (Mr. Merivale) that any economy in the system of secondary haulage in this district must be

* *Trans. Fed. Inst.*, vol. xii., page 257; and vol. xiii., page 117.

sought on the lines which Mr. W. Lishman tried for some years (and from a mechanical point of view, with complete success) at the Lambton collieries, namely, with some form of locomotive (either compressed air or electrical). He did not see how any system of ropes could be carried into the working-places.

Possibly some of the members might have seen the recent proposal, or in fact the working model of a railway which might be adopted in mines, the idea being that great speeds could be employed. By the system to which he referred the lines were laid in hinged sections, and by hydraulic or other means, the ends of such sections were lifted in rotation, so that the trains were always running down hill. At first sight the idea seemed to be as impossible as that of sinking pits through running-sand by freezing the water, but they knew that this had been done; and who would say that it was impossible with level seams and with the power carried into the face (as would no doubt become the case when coal-cutters were more universally adopted) and with sufficient height to raise the tubs 1 foot, that such a system might not be carried out? The rails would be raised in sections, say, by compressed air and the tub run down, say, about 60 feet, and then the next section would be raised, and so on, and when the empty tub was brought back this process would be reversed.

But after all there was not such a great margin for economy as Mr. Galloway seemed to think. He compared pony-putting with ordinary haulage on engine-planes, and he put down the cost at 2½d. per ton-mile as against pony-putting at 2s. 2½d. per ton-mile.* These figures might be correct, but it seemed to him to be as fallacious as comparing the winding of coal by a winding-engine with the lifting of it into the tub by the hewer. They might as well say the cost of winding coal was 1d. per ton per 600 feet as compared with about £1 per ton for the same distance by the coal-hewer. The distance which the coal was put was very short: he believed 150 yards was something like the average rather than 250 yards, which Mr. F. R. Simpson referred to, and if they took Mr. Galloway's figures this would reduce the cost to about 2d per ton, and although the slight reduction upon that was not to be despised (say, 10 per cent.), 10 per cent. on 2½d. per ton as compared with 10 per cent. on 2s. 2½d. was a very different thing. It must be remembered that the cost was not 2s. 2½d. per ton but 2s. 2½d. per ton-mile, a very different thing.

* *Trans. Fed. Inst.*, vol. xii., page 277.

Mr. Frank R. Simpson said that he did not wish to convey the idea that 250 yards was the average length of pony-putting in the North of England; it would be a distressing thing in any case if they got so far as that.

Mr. T. E. Forster said that he quite agreed with the remarks of the previous speakers. When people started to compare things on a basis of the ton-mile, the comparisons were sometimes made in the most fallacious way. He thought to some extent that this was so in the case of the report of a committee of the North of England Institute of Mining and Mechanical Engineers on haulage:* what they ought to do was to take the work actually done. In South Wales, very large tubs were used, while in this district even an 8 cwts. tub was somewhat exceptional. The cost of hauling, driving, and putting was certainly much less than Mr. Galloway assumed, and such cost would in their case be altogether out of the question.

The President thought, however, that there was room for improvement in the North of England. The 150 yards spoken of as being the work of putting ponies, if it could be kept to that, would be very economical, and they could not very much improve upon it, but no doubt there was the question of dealing with the tubs after this 150 yards from the face and to the engine-plane. It was a difficult thing where they had a lot of districts to be able to get the hauling-ropes within 100 yards of the face. Mr. Galloway could not help them very much with their pony-putting, for they were very much better off in this respect than they were in South Wales. In the case of one of the collieries under his charge, compressed air and small haulage-engines were used to work small sets of tubs from the face to the main haulage-road. The compressed-air locomotives mentioned by Mr. Merivale could not be used to any great extent unless they had level roads. The difficulty was to some extent got over at a colliery in Yorkshire by an electric locomotive engine fitted with a hauling-drum. It was used to haul the tubs up the steep roads with a rope, and then became a locomotive on level roads.

Mr. Frank R. Simpson said that the system of rope-haulage to which he referred was to take side by side two ropes between a single line of rails, the sets being gripped on in convenient numbers to either rope.

Mr. W. Galloway wrote that it would have been much more satisfactory to him, as the writer of the paper, if Messrs. Simpson, Merivale,

* *Trans.*, vol. xvii., Appendix No. I.

and Forster had given figures taken from actual practice to illustrate their arguments, instead of contenting themselves with a series of general statements. The latter course did not bring us appreciably nearer to the desired goal, but left the subject as indefinite as it was before.

He thought that Mr. Merivale would, upon again looking at his paper, see that he (Mr. Merivale) had made a mistake when he stated that pony-putting was compared with ordinary haulage on engine-planes in that paper, as if the two things were in some sort comparable. He (Mr. Galloway) had endeavoured from the beginning to the end of his paper to keep the two things quite distinct, and to point out the fundamental differences between them. This was the reason why he had chosen the title "Secondary Haulage" for his paper, in order to distinguish it from what he called "primary haulage," and he thought that, under these circumstances, the charge would have to be withdrawn.

He (Mr. Galloway) had made a comparison between two systems of secondary haulage, for each of which he had exact data. One of them was in the act of being introduced under adverse circumstances: the gradients were, in many places, against the load, and in some places so steep that pony-putting would have been impossible; the districts were small and scattered, for the reasons explained in the paper; and the officials were more or less indifferent, and hankered after horse-haulage. The other system had been in use for many years, and had been brought to the last degree of perfection of which it was capable under the fostering care of world-renowned engineers and managers, and in a coal-field and under circumstances in which every condition appeared to be favourable to it.

He did not for a moment pretend or wish it to be understood that he considered the use of small engines, wire-ropes, and large tubs to be a final and conclusive solution of the question of secondary haulage. It might or might not ultimately prove to be a link in the chain of evolution. He thought that he had been able to show that it could at least hold its own, even when working under the unfavourable conditions which he had described, when pitted against pony-putting working under favourable conditions. The conclusion seemed to be inevitable that, given the same conditions in both cases, the small engines, wire-ropes, and large tubs were the more economical. He was however open to conviction, and all he asked for was a statement of facts and well authenticated figures, and not opinions or generalities.

He might say in conclusion that his own early experience was with small tubs carrying, some 6 cwts., others 12 to 14 cwts., and that when he

first came in contact with large tubs carrying from 25 to 40 or even 45 cwts., he felt as much prejudice against them as anyone could have had who had spoken during the discussiou. But as time went on his views had gradually undergone modification, until at length he felt quite unable to appreciate the supposed advantages of the small tub. The argument as to derailment had a plausible ring about it that was not borne out by the results of practical working. A moderate degree of care in laying the roads, providing rails of sufficient strength for the weight to be carried, regulating the curves to suit the gauge of the rails, and having the flanges of the wheels deep enough to correspond to their diameter and to the radii of the curves, reduced the numbers of derailments to a very small figure. Heavy tubs ought never to be handled by men except upon falling gradients; and mechanical appliances ought to be used upon a dead level and on all rising gradients. If these fundamental rules are attended to, the employment of heavy tubs becomes as simple and of as easy application as that of light tubs. For instance, at the top of a shaft the writer has handled 800 tons per day (including stoppage on the weighing-machine and tipping), with tubs carrying on the average 2 tons of coal each, by means of 3 men and a boy—one of the men acting as banksman and giving all the signals. Three men did all the work at the bottom of the same shaft at the same time. The tipping was, of course, done by mechanical power, and the empty tubs were raised to a height of 6 feet or so on an inclined plane, worked by means of a chain with knobs fixed on it at certain distances apart which caught behind the axles of the tubs automatically, and after pushing them up to the top of the incline released them automatically and allowed them to run round to the back of the shaft on a downward gradient.

The writer thinks that there cannot be two opinions as to the advantages of a large tub, both on engine-planes and in winding. The only refuge left to the advocate of the small tub is, therefore, in secondary haulage, and that refuge (as the writer has endeavoured to show in his paper) does not appear to be a very secure one.

The following paper was read by Mr. G. B. Reynolds on "A Method of Dealing with Running-sand when met with in Borings":—

A METHOD OF DEALING WITH RUNNING-SAND WHEN MET WITH IN BORINGS.

By GEO. B. REYNOLDS.

The difficulty experienced on meeting with sand in boring operations at any time is considerable, as sand, when wet as it usually is in such cases, presents great resistance to the insertion of the casing, and if attempts be made to drive it down, the casing may collapse or telescope. Further, it may happen that the engineer conducting the boring operations may have no more casing on the ground than will be sufficient, without accidents, to finish his borehole, and if abroad, some months' delay will result if he alters the size of the hole, owing to inability to buy the tubes he may, under the altered circumstances, now need.

Under conditions resembling those mentioned above the author adopted the plan which he will now describe, and he hopes that the method may prove of as much use to others as it was to him. Recourse was had to the expedient about to be described when the author was conducting boring operations for the government of India in proving the Warora coal-field in the Wardah Valley of the Central Provinces. Th method successfully adopted in India may be of use anywhere where the strata are soft and sandy, and calculated to cause trouble in boring.

At Warora, the strata overlying the Coal-measures consist of soft sandstones and clays, and the upper coal-seam is overlaid by a seam of fire-clay about 10 feet thick.

It was expected to strike the white sandstone in the hole where the running-sand was met, at a depth of about 900 feet, after which it was considered useless to bore further in search of coal. This, then, was assumed to be the limiting depth of the hole, and the boring was arranged for accordingly.

Knowing that serious loss of time would follow any stoppage of boring work for want of tubes—and desiring to leave no tubes in the hole when it was finished, but to withdraw them all—the tubes first inserted were made at the shop at the mines on the Lentz method as used at Baku.*

In putting down these tubes, which could not of course, from the nature of their construction, stand much driving, the running-sand was

* *Petroleum and its Products*, by Mr. Boverton Redwood, 1896, vol. i., page 286.

found, and they were forced into the sand by blows of a monkey as far as was deemed safe short of telescoping them. These tubes were some 12½ inches in diameter, and when driven down as far as possible, steel tubes, flush jointed (10 inches in diameter), were inserted and driven into the sand, as far as possible, in advance of the larger tubes.

It was desired to force a grouting of Portland cement through the inner tube, allow it to set, and then to drill through the sand, which would be, it was hoped, solid and self-supporting when cemented by the cement.

Two methods of pumping the cement grouting into the sand below the casing may be used. The first method is to put a cap on the top of the tube through which the cement is to be forced, and to connect this cap by a pipe with a donkey-pump, and so force in the liquid grouting. This method was not adopted, as a certain amount of delay would be involved in making the cap so needed, none being procurable ready made.

The second method is to use the tubes as a pump-barrel, the boring rods as pump-rods, and on these last to fix an inverted pump-bucket of wood with leather clack-valves, and so pump the water standing in the tube downwards, with the cement, into the sand below. A reciprocating motion is given to the rods by the drilling-engine, and they are weighted with tubes to enable the bucket to force the water down. The expedient was a rough one, but answered its purpose, and had the merit of needing only such simple appliances as could be readily made by an ordinary native blacksmith and carpenter on the spot.

Had these ready means not been effectual, the author would have had recourse to the former method, which would have been more expensive and caused delay.

To prevent the grouting from rising between the inner and the outer tubes, and so diminishing the head caused by the pumping, soft, dry wooden wedges were driven, at the top of the outer tube, into the annular space between the two tubes, and thus reduced any loss to a minimum.

The sand, in the instances under description, was found at only a small depth from the surface, but the method is applicable at whatever depth the sand may lie, and requires only the insertion of a tube a short length into the sand down which the cement can be pumped.

The idea was, the writer thinks, suggested to him by reading the articles by Mr. W. R. Kinipple, in *Engineering* of May 20th and 27th, 'Underpinning by means of Grouting and Stock-ramming,"* and he trusts that the method may be of use to others.

* Vol. liii., pages 609 and 646.

Mr. A. L. Steavenson asked what was the thickness of the sand, and whether, when the hole got through the cement, the boring was continued. There was one system of boring through sand (which the writer had not mentioned) by forcing water down under pressure, which washed up the sand and allowed the pipes to go quickly down. He also asked how far the cement passed into the sand below: did they bore through the cement afterwards, or did the cement simply cake round the bottom of the tube?

Mr. T. E. Forster said that it appeared to him that the cement was pumped down the inner tubes and united with the sand into solid stone, which was then bored through.

Mr. F. Coulson said that it would be interesting to know the thickness of sand below the bottom of the pipes, and whether there was any pressure of water coming from the sand. The system of putting cement into bore-holes had been adopted, to his knowledge, for 30 years for securing loose ground, but he could not imagine, in the case of quicksands where there was not much water, that it would be possible to force the cement any great distance into it. It would set hard for a certain distance, but there would be again the quicksand below to contend with. In addition, there were some kinds of water met with in bore-holes in which cement would not set, although tried with all kinds of cement in many different ways. As Mr. Steavenson had suggested, possibly the best known method of getting through quicksand was to force water down under pressure and rotate the pipes, and they would go down very rapidly.

Mr. G. B. Forster suggested that the forcing down of the cement was probably repeated if the thickness of the sand required the treatment. He had pleasure in proposing a vote of thanks to the writer of the paper.

Mr. Merivale seconded the proposal, which was cordially adopted.

Mr. G. B. Reynolds, replying to the discussion, wrote that the thickness of the sand was, as far as his memory served him, 12 or 14 feet. Above the sand there was a seam of clay, and when this was pierced by the boring-tools the water rose about 15 feet in the staple-pit in which the men were working. This pit was 18 feet deep below the surface of the ground, so that to continue boring a donkey-pump, which was worked as occasion required, was placed in the pit, till, with the advance of the hot weather, the water took off. The sand being so full of water, no difficulty was experienced in forcing into it the cement-grouting. If the cement did not reach the lower limit of the sand, there

was no difficulty in repeating the process as often as necessary where the drill proved that the sand was not self-sustaining. Had there been no water, or but little water, in the sand, it would have been easy to add water in excess to the cement at the top of the hole and pump it down. The boring was continued to a depth of over 650 feet below the bottom of the sand. The hydraulic system of boring alluded to by Messrs. A. L. Steavenson and F. Coulson was known to him (Mr. Reynolds), but he had not the necessary appliances at hand, and so adopted the ready method which he had described in his paper. The gist of the paper was the description of a cheap and ready method of dealing with the sand, and one not involving any special plant.

The following paper by Mr. W. L. Austin on "Pyritic Smelting" was taken as read :—

PYRITIC SMELTING.

By WM. LAWRENCE AUSTIN, Ph.D., of Denver, Colorado, U.S.A.

Introduction.

Under pyritic smelting is understood a smelting process which aims at utilizing the calorific power of an ore.

Pyrite (FeS_2), chalcopyrite ($CuFeS_2$), pyrrhotite (Fe_7S_8), arsenopyrite (FeAsS), blende (ZnS), galena (PbS), etc., are all ores which have calorific values as metallurgical fuels, and it is with the utilization of this quality in such ores that pyritic smelting has to do.

When a smelting ore contains in itself the fuel necessary for its concentration into a product which can be transported to market and sold at a profit, that the most rational way to beneficiate it is to turn this property to account, would seem to be so self-evident a proposition as not to admit of argument. Yet the common practice is to destroy such natural fuels by calcination, and then smelt, with the help of coke, etc., the oxides thus produced.

Why should we burn (roast) an ore which contains in itself a sufficient quantity of potential heat units to smelt it, and then smelt the burnt product with the assistance of more or less expensive fuel? Or, even when such an ore is smelted raw, why should we melt it down with coke —as if it were pig-iron for foundry purposes—although we may have dispensed with the preliminary roasting? In either case such a proceeding must be considered as wasteful and extravagant, if it can be shown that a heavy sulphide ore contains in itself a source of heat which, when properly applied, will suffice for maintaining a smelting temperature.

One would not think of employing wood to keep up a coal-fire after it has once been started, for we all know that when the coal has been kindled, that is to say, when once the temperature has been raised to a point at which the elements composing what we term coal are able to unite with oxygen, then the mineral continues to burn of itself and any addition of wood becomes superfluous. The same is the case with iron pyrites. When this mineral has been raised to a temperature at which its component parts are free to unite with the oxygen of the air, further use of kindling is equally as unnecessary as in the case of coal, and in the proper apparatus the combustion can be made self-sustaining.

We see this statement verified in the every-day practice of heap-roasting. In this process, pyrites is placed on kindling, and covered with fine material so as to make it possible to regulate the admission of the air to the pile. Once ignited by the kindling, the whole mass continues to burn until the sulphide is practically converted into oxide, so far as the imperfections of the method of treatment will permit. In the modern pyrites-burners used by sulphuric acid manufacturers, the oxidation is much more thorough than in open-air heap-roasting, and no kindling is necessary after the kiln becomes sufficiently heated. But in either case, the combustibility of the pyrites itself is relied upon to accomplish the end in view, and the carrying out of these processes demonstrates that once ignited pyrites will continue to burn until the sulphur is practically all eliminated and the iron is converted into oxide. It only remains, therefore, to burn the pyrites more rapidly in order to produce a temperature which is high enough to fuse the whole mass, and this actually takes place unless care is exercised in restricting the amount of air admitted to the kilns.

Pure iron pyrites is a compound of iron and sulphur in the proportions by weight of 46·66 of iron to 53·34 of sulphur, and both of these elements may be burned in air when the proper conditions are provided to effect their combination with oxygen. Everyone knows that sulphur will burn, but the layman is often disposed to accept with incredulity the statement that iron can be utilized as a fuel. That the metal of which modern fire-proof buildings are so largely constructed is capable of burning with a fierceness which rivals that of coke, is to him an utter absurdity. Still he knows that when an iron bar is heated to a high temperature in a forge, it will burn and emit brilliant sparks. In burning iron much depends upon the extent of surface exposed to the action of the air. A heavy bar with a surface relatively limited as compared to its bulk can only be made to burn with difficulty under ordinary conditions; but finely divided iron, prepared in a chemical way, will catch fire of itself if exposed to the air;* and iron in the state in which it exists at the instant when it separates from the sulphur with which it is combined in iron pyrites, ignites even more readily. Metallic iron is, therefore, a combustible, and all that it is necessary to do in order to burn it, is to provide the necessary apparatus for carrying out the operation in conformity with the laws governing the use of this class of fuel.

* According to Magnus, metallic iron may be reduced from ferric oxide by hydrogen gas at a temperature lower than the boiling-point of mercury. This iron is a black powder, and is so pyrophoric—on account of its porosity—that it catches fire in the air and burns.

However, the combination of iron and sulphur in iron sulphides of whatever class is not a combustible so long as the two elements are united. They must first be dissociated from each other in order to be free to enter into combination with another element, and it is only after such dissociation has been brought about, and the two elements find themselves in *status nascendi*, that their combustion may be effected. To dissociate these elements from each other, a certain amount of mechanical work must be done, and in the pyritic furnace this work is performed by heating the compound up to a certain point, when the elements separate from each other, and, if the proper amount of oxygen be then provided, they will unite with it. When suitable apparatus is used for carrying out the combustion of iron sulphide by forcing its elements into combination with the oxygen of the air, the heat generated is sufficient to fuse the resulting ferrous oxide, carry off the sulphurous acid gas produced by the burning sulphur, and at the same time to effect the dissociation of the next portion of the sulphide to be operated upon. If silica be present to make a fusible slag with the molten ferrous oxide thus formed, then the sulphurous acid gas passes upward with the heated nitrogen, and the molten slag falls downward into a vessel prepared for its reception, and we have a smelting operation. When means have been taken for supplying the proper proportions of air and pyrites in a manner conforming to the conditions under which they can best unite, the smelting will not differ materially, so far as the appearance of the furnace is concerned, from the usual operation with coke or charcoal, only in this case the pyrites supplies both the fuel and flux.

That iron pyrites contains in itself the potential heat units requisite for its own smelting may be demonstrated by thermal calculations,* or ocular evidence of the fact may be obtained by observing a Manhès converter in operation. In the so-called bessemerizing of copper-matte (a process in such general use at the present time as not to require detailed description here) the molten iron sulphide is run into a converter, and air is blown through it until practically all the iron is burned off, the combustion of the iron (and incidentally of the sulphur associated with it) sufficing to keep the mass at a high heat and extremely liquid during the operation. Anyone who has watched the working of such a converter can have no longer any doubt about the fuel qualities of iron sulphide, for the treatment of matte in these vessels is actually a smelting operation, although of limited duration

* For thermal calculations on pyritic smelting, see the *Berg- und Hüttenmännische Zeitung*, 1894, vol. liii., page 217.

owing to the unsuitability of the converter for a continuous smelting of ores. That it is not, as many think, wholly the sulphur which supplies the heat is shown by the fact that the sulphide treated in these converters is largely iron monosulphide (FeS). Hence it is evident that the iron pyrites (FeS_2) after losing one atom of sulphur in a preliminary melting still retains more than enough potential heat units to suffice for a smelting operation. In fact, iron pyrites reduced to the form of matte and deprived of 50 per cent. of its sulphur is a better fuel for smelting purposes than was the original ore, for the raw ore possesses the quality of decrepitating, and flies to pieces when heated, causing dust troubles when precautions are not taken to obviate this difficulty, whereas the matte melts down quietly, and is for that reason more desirable. On account of the fuel qualities possessed by matte it can be used to smelt a charge of siliceous ore, proper consideration being had for the relative proportions of iron and silica necessary in forming an easy melting slag.

What has been said in regard to iron pyrites and matte as fuels, applies equally to any of the combinations of iron with the metalloids of the sulphur group (sulphur, arsenic, or antimony), and in a measure also to their combinations with zinc, lead, copper, etc. Pyrrhotite, arsenopyrite, chalcopyrite, marcasite, speiss, etc., are all suitable for treatment by the pyritic smelting-process.

If, as has been shown above, iron pyrites contains in its combustible elements a sufficient quantity of potential heat units to support a smelting operation, then the use of carbonaceous fuel to smelt such ores is sheer waste, provided a suitable apparatus can be obtained for turning this quality to economic advantage. Assuming for the present that such an apparatus is at hand, then the beneficiation of deposits of this mineral, so low in grade as not to permit of profitable treatment by metallurgical processes heretofore in use, is rendered possible by the fact that it is no longer necessary to carry expensive fuel to them, nor to transport such ores to smelting centres where cheaper fuel is available, for they can be handled much more economically at the mines themselves.

Pyritic smelting should be regarded, not as a smelting process in the usual acceptance of the term in the western portion of the United States, involving all the complicated operations ore is subjected to in the large smelting establishments at Denver, Kansas City, Omaha, and elsewhere, but it should be looked upon as a method of cheap concentration (fire-concentration is an appropriate term), and pyritic smelting-plants will

find their proper sphere when placed on the dumps of those mines whose ores are suitable for treatment by this process. Such a fire-concentrator situated at the mouth of a shaft or tunnel, so that the ore could be run out from the mine in mine cars and dumped into the shaft of the furnace without further handling, would naturally effect a great saving in the expense of operating such properties. If the freighting, crushing, sampling, bedding, calcining, and coke-smelting of low-grade ores were done away with, it is evident that the expense of treating them would be greatly reduced. In handling low-grade concentrating ores, where water is used for concentration, the raw ore is dumped into the concentrator, and an effort made to produce a concentrated product at the minimum of expense. Why make an exception in the case of fire-concentration and encumber it with so many unnecessary details? Or why should the owners of deposits of this class of ore continue to pay high transportation and smelting charges, which often render the working of their mines unprofitable, when it lies in their hands to concentrate their values at the mines before shipping, exactly on the same general plan as the values of low-grade siliceous ores are often concentrated in wet-concentration mills? In a well-managed mine the excavation of the ore is controlled by assay in any case, so that its value is known before it is mined, and thereby the cost of taking out worthless material is avoided. Such preliminary assaying is all that is necessary where a fire-concentrator is used, and there is no reason why the crude ore, just as it is mined, should not be dumped into the hoppers of a fire-concentrator, as it is dumped into the rock-breakers of a wet-concentration mill. This is admissible in pyritic smelting, although it might be considered unadvisable in other smelting methods. To make this point clearer we will consider the characteristics of the two methods of smelting.

In the case of an ordinary lead- or copper-smelter we have a mass of inert mineral matter which we fuse down into various furnace-products by the help of carbonaceous fuel. The charge remains in the shaft of the furnace, until the carbonaceous matter has been burned up and the ores and fluxes brought into a state of fusion. We can, therefore, calculate with safety that the elements contained in the charge shovelled into the top of the stack will group themselves according to known laws into slag, bullion, matte, etc., which will be found in the crucible of the furnace arranged in the order of their specific gravities. But in pyritic smelting the case is entirely different. The ore and the fuel are one, and just how much of the iron contained in the iron

sulphide will be burned to oxide and how much will be left as matte is wholly a matter of furnace conditions. The relative proportions of the elements in the furnace-charge are, within certain limits, of minor consideration, as the furnaceman has it in his power to alter the proportions of matte and slag issuing from the furnace, regardless of the actual chemical analysis of the charge. For this reason ore-bedding is superfluous, and the furnaceman by changing the heat or pressure of his blast, and by the addition of more or less siliceous material, or by modifying certain other conditions, can regulate the relative amounts of matte and slag to suit his wishes. By allowing for the proper subsidence of the molten products, that is, by giving them time to separate, and by looking after the specific gravity of his slag, the latter can always be kept sufficiently clean. So that the whole matter resolves itself into one of practical experience with this particular method of ore-treatment, the operations being guided by the eye rather than by chemical analysis.

Nor does the size of the material handled seriously affect the results. As has already been stated, the natural sulphides decrepitate when exposed to heat, so that however large the size of the pieces when put into the top of the furnace, by the time they reach the smelting-zone they are in a fine enough condition for smelting. For these reasons ore can be thrown into a pyritic smelting-furnace in any size which will permit of handling in the mine, and its further comminution results as a natural sequence.

Hence, it is not only possible, but economically advisable, in the case of low-grade heavy sulphide ores, to locate a plant as near the deposits as practicable, and to dump the raw ore just as it comes from the mine into the top of the fire-concentrators, and to regulate its smelting by changing the furnace conditions to meet the requirements in each case. The same rules which govern the erection of water-concentrators (which are usually placed at points convenient to the mines so as to avoid the freighting of valueless material) apply in the case of fire-concentrators.

By utilizing the sulphides themselves as smelting fuel, and modern gas-engines as motive power for the blast, etc., it is possible to matte a suitable sulphide ore with an expenditure of less than 4 tons of coal for each 100 tons of ore treated, including fuel for power and for heating the blast. Add to this the labour-saving devices now in use for charging, and removing the waste-products, in furnaces of modern construction—some of the large iron furnaces lately built employ no men at all on top—and it can be readily seen that fire-concentrators may be

operated under favourable conditions at a very low figure, even for less than the usual cost of wet-concentrating, and, as will be shown, with a higher saving of values.

Ores Adapted to Pyritic Smelting.*

The first requisite in an ore to fit it for pyritic smelting is that it should contain enough iron combined with sulphur or arsenic to make an easily fusible slag, and to provide for a matte-fall sufficient to cover the valuable metals contained in the charge.

With regard to fusibility, practice has shown that the best slag for the process is a monosilicate—one in which the oxygen of the silica is equal to that of the bases. To form such a slag requires different amounts of the various bases in common use. For instance, an iron monosilicate calls for 29·41 per cent. of silica to 70·59 per cent. of ferrous oxide; a similar lime silicate requires 34·88 per cent. of silica to 65·12 per cent. of calcium oxide. Substituting magnesia for the lime, we need 42·86 per cent. of silica for 57·14 per cent. of magnesium oxide; and for aluminium, 46·68 per cent. of silica to 53·32 per cent. aluminium oxide, and so on.

Now, to make a ferrous monosilicate slag requires approximately 4 tons of pure pyrites to 1 ton of pure quartz, so we may say that for slagging purposes alone we need an ore-mixture containing 80 per cent. of pyrites and 20 per cent. of silica; but that is using up all the iron on the slag, and does not allow for any matte-fall.

It is a well established fact in smelting that a complex slag, that is to say, one containing a mixture of various bases, is usually more desirable than one consisting of only one base and silica. In other words, a lime-iron slag, or one carrying lime and magnesia, or one containing a number of basic elements, iron, manganese, calcium, magnesium, aluminium, etc., is more easily fused, and possesses other more desirable qualities than simpler slags. Therefore, where it is possible, we aim at making a slag containing several bases.

If the ore-charge be composed of pyrites and quartz in the ratio of 4 to 1, and we add to it limestone, we can form a lime-iron slag, still preserving our monosilicate, and then have iron sulphide in excess which is free to form matte. The addition of lime has another advantage, as it lightens the specific gravity of the slag and renders it more easy to separate from the matte.

* This subject was discussed in the *Mining and Scientific Press*, 1893, vol. lxxii., page 440.

If limestone be not available, we can still form a monosilicate slag, and provide for a matte-fall as well, by decreasing the amount of silica, or by substituting some other base. In some cases, it is even found desirable to make a more siliceous slag, the iron of the sulphide being prevented from burning to ferrous oxide by slightly altering the furnace conditions.

When an ore is not of the desired composition—that is, when it does not contain 80 per cent. of iron sulphide—other expedients must be resorted to; but it has been found in practical work that an ore-mixture of the composition given will smelt readily without the assistance of carbonaceous fuel in the furnace, and will produce enough matte to effect a saving of 95 per cent. of the valuable metals which it carries.

It is therefore obvious that pyritic smelting finds its limitation in the amount of silica contained in the ore which it is desired to treat, and the question whether or not a given ore is suitable for the process, is one which can be decided by chemical analysis. However, with practice the operator can often determine by simple inspection whether his ore possesses the desired qualifications, but in cases of doubt a silica determination will set the matter at rest. Often simple panning will give all the information necessary. If a few pounds of the ore be ground up, the pulp weighed, and concentrated in a pan, the weight of the resulting sulphides will allow one to make a pretty close guess at the relative amounts of pyrites and quartz in the material under investigation. All that is necessary to be decided is, does the ore contain enough iron in the form of sulphide or arsenide to flux off the silica and form a monosilicate slag? If not, are there other bases available in the neighbourhood to make up the deficiency in iron? Of course, every metallurgist is aware that certain combinations can be made between the various bases which will produce very fusible slags even when a monosilicate is out of the question, so where the case is not as simple as in the ideal proposition discussed above, it is always well to consult an experienced metallurgist. The physical condition of the ores—whether coarse or fine—is not a matter of great importance. There are various cements which can be utilized for cheaply and firmly binding even the finest concentrates into forms suitable for blast-furnace work, and furthermore, with the improved type of pyritic furnace, fines do not interfere with the operation. It must be borne in mind that under any circumstances, no matter how coarse the raw pyrites may be, it decrepitates to fines under the influence of heat, and this fact must be taken into account in handling such ores in the raw state, much depending upon the form of furnace used for the purpose.

The influence of zinc in pyritic smelting is one of considerable importance. The sulphide of zinc (blende) has nearly the same thermal value as the pyrites. Where Mr. Hollway found by calculation, the temperature produced by the combustion of protosulphide of iron to be 2,225° Cent., he estimated in the same manner the temperature resulting from the combustion of zinc sulphide to be 1,992° Cent. So that up to a certain point any blende contained in the sulphide under treatment assists the operation by its heat-producing powers. But there are other qualities possessed by this mineral which render it not so desirable a fuel as iron pyrites. The burning of zinc produces zinc oxide, and the silicate of zinc is not as fusible as that of iron protoxide. However, if the different bases be combined in certain proportions they mingle readily, and in practice, 14 per cent. of zinc in the charge has shown no deleterious results. This is the greatest amount of zinc yet reported in a pyritic smelting-charge, but is not regarded as the limit attainable, and it is probable that a much higher zinc contents can be advantageously used. The zinc oxide, being a base, materially helps out any deficiency in iron, for the zinc is disposed to go into the slag rather than into the matte. Much of this metal is also carried off in the fumes, and in a properly-constructed furnace every opportunity is given to assist its volatilization.

The arsenic, when arsenide of iron is used in the place of sulphide, separates from the iron readily under the influence of a pyritic furnace, and volatilizes, leaving the iron free to unite with oxygen. The results produced from burning arsenide of iron have been almost, if not quite, as good as where iron pyrites was used. The arsenic burns to arsenious acid and goes off in the form of heavy white flakes, which may be caught in suitable dust-chambers. The burning of the arsenic yields also its quota of thermal units to the operation.

According to Mr. Hollway's calculations the temperature produced by the combustion of sulphide of lead is 1,863° Cent., so that any galena present in a pyritic charge is of assistance in producing heat. The lead itself is difficult to save. Some goes into the matte, but a large proportion is either volatilized as sulphate, or is oxidized and goes into the slag, materially assisting in rendering the latter fluid.

Style of Furnace.

In the experimental stages of pyritic smelting, circumstances compelled the use of whatever apparatus was at hand. For this reason blast-furnaces were employed, which had been built originally for other

methods of smelting, and it is largely due to this precedent that furnaces intended for pyritic smelting continue to be built on similar lines, without sufficient consideration being given to the peculiar conditions under which they are to be operated. It appears to be difficult for furnacemen to grasp the idea that for a totally different fuel a different style of apparatus is not only advisable but necessary, and that no matter how well a furnace may be adapted to smelting with coke, when it comes to using pyrites in the place of the first-named combustible a different condition of things has to be reckoned with, and the coke-furnace is no longer suitable. Unless this fact is given due consideration, and the new conditions are carefully studied and provided for, the results are apt to be disappointing. When we hear of experiments being tried with old furnaces, if the results do not come up to anticipations it will usually be found to be due to the fact that the experimenters have not a clear insight into the nature of sulphide fuels, and have attempted the impossible.

That furnaces built on the lines of those intended for lead-ore smelting are not adaptable to pyritic smelting purposes becomes all the more patent, when the two classes of fuel used in the respective processes are considered.

In the first place, coke (which for all practical purposes may be considered as a single element) unites directly with the oxygen of the blast; whereas the sulphides are compounds of sulphur with some other element, and this union must first be broken up before the component elements can unite with oxygen. When the elements of a compound must be dissociated before they are in condition to burn it is evident that a certain amount of preliminary work must necessarily be done, and owing to this preparatory work the sulphides are at a disadvantage in a coke-burning furnace. The result is that where the two fuels—coke and sulphides—are simultaneously operated upon, the coke, which is already in condition to oxidize, is attacked first, and the sulphides are simply melted down and run out of the furnace without being burned to any great extent as long as the coke lasts. This is a partial explanation of the difficulty experienced by experimenters in effecting a proper concentration of the matte, for where the conditions are adverse to the burning of the iron sulphide, it naturally follows that the concentration is poor.

The fact that coke has a much greater exposed surface than that presented by the sulphide-globules, plays also an important part in the selective action of the oxygen of the blast. Coke is a more or less porous mass, and the air penetrates into its innumerable small cells, which

afford the blast a very large surface to operate upon. Pyrites, on the other hand, is a dense metallic substance, which melts in the upper part of the charge, and, losing one atom of sulphur, forms globules of monosulphide equally impervious to the blast. The latter can therefore only work upon the limited surface of these globules, and is restricted in its action as compared with the opportunities presented by the very much larger exposed surface of the coke. So the sulphides are handicapped in an ordinary furnace, firstly, by the necessity of dissociating their elements, and, secondly, by the small extent of the surface that they offer to the blast.

But this is not all: the coke is practically stationary, being held in its place in the charge by surrounding mineral matter until it has been wholly consumed, all the time requisite for the action of the blast being afforded. The monosulphides, however, are in the form of heavy mobile fluids, which rush down through the interstices of the charge, allowing only time for momentary action of the blast. Time is therefore an element of the greatest importance in the combustion of sulphide fuels, for unless the blast is given an opportunity to work on the iron sulphide, little of it will be oxidized, and for this reason also the concentration will be slight.

To sum up, we have in coke a solid, consisting of a single element with a large surface exposed, which is retained in position until consumed: in the sulphides, heavy liquids of very limited surface, requiring dissociation of their elements before the oxygen can act upon them, and which rush through the charge in the briefest possible time. Surely it is unreasonable to expect that an apparatus designed for burning the former class of fuel will be equally efficacious in the case of the latter!

In addition to the behaviour of these two classes of fuel while under the action of the blast, we have also to consider the products of combustion resulting from the two operations. In the case of coke, these are gases—largely combustible gases—which pass upward through the charge, carrying heat with them, and in this upward passage act upon the descending minerals. With sulphides, the products of combustion are principally heavy fluids, which drop downward. The amount of heat carried upward by the sulphurous acid gas and the nitrogen of the air is comparatively small, and may be neglected. When zinc, antimony, arsenic, or lead are present, a volatilization of portions of these elements in their oxide forms will take place, but this is of small moment, and may be overlooked in the discussion of the behaviours of carbonaceous

and sulphide fuels in the blast-furnace. The necessary point to be considered is that in coke-burning furnaces the heat travels upward; in sulphide burners it follows the molten products of combustion downward, necessitating the fortifying of the lower part of the furnace against the intense action of the basic slag and matte.

It is evident, therefore, that in handling these two different combustibles we have got to meet the conditions in each case on wholly different lines if we are to expect satisfactory results.

Firstly, the fusibility of the sulphides precludes the use of high smelting-columns. If we take an ordinary lead-smelting stack, with a distance of 12 or more feet between the plane of the tuyeres and the feed-floor, and charge it up to the doors, we have a smelting-column altogether too high for pyritic smelting purposes. Such a column is necessary for various reasons in lead-ore smelting, and the mass is kept open to a great extent by the fuel burning away so that the blast penetrates to all parts of it: besides, it is desirable that the ascending carbonaceous gases should be given an opportunity to act upon the descending charge and prepare it for the fusion which is to take place in the neighbourhood of the tuyeres, by reducing the ferric to ferrous oxide, driving off moisture and carbonic acid, reducing lead to the metallic state, etc. But in pyritic smelting there should be no carbonaceous fuel to burn away, nor oxides to reduce, and where a high column is used a softening of the sulphides takes place in the upper part of the charge, which adhere to the walls of the furnace and produce a more or less solid mass which the blast cannot penetrate, and which hinders the even descent of the material to be operated upon. For this reason, in pyritic smelting any action of the ascending gases upon the charge is to be avoided if possible.

In pyritic smelting, as there is no necessity for a preparation of the charge before it is brought into a state of fusion, what is wanted is to melt the whole as quickly as possible without permitting a preliminary matting together of its component parts. Therefore, the high smelting-column is a distinct disadvantage, and where it is used, it is also necessary to have more or less coke mixed with the charge to keep it open. With the use of coke, the advantages of the process disappear to a great extent, for apart from the cost of the coke, the two classes of fuel cannot well be used together, for reasons already given.

The best height for a smelting-column in pyritic smelting is one which will present a sufficient resistance to the upward tendency of the

blast to cause the latter to penetrate to the centre of the charge. This, of course, varies with different sizes of furnaces; a wide furnace requiring a deeper charge than a narrow one.

In order to be able to regulate the height of the smelting-column and keep it stationary, recourse is had to an interior feeding-cylinder. This contrivance is so adjusted as to deliver the sulphides at a given point in the furnace-shaft, and at the same time protects them from the action of the escaping gases. In this way, a constant height of smelting-column is maintained and the sulphides are delivered at a point where smelting takes place without permitting an incipient fusion, the heated gases being directed into other channels prepared for them.

Secondly, as the sulphides must first be dissociated before their component elements can combine with oxygen, a considerable amount of heat is absorbed in doing this work. Now, owing largely to the absorption of heat in performing this extra work, if the blast be blown on the sulphides at the ordinary temperature of the air, the extent of surface presented by the globules of molten sulphide is so limited that the heat of combustion is not sufficiently concentrated to fulfil the threefold requirement, of dissociating the iron from the sulphur, bringing the temperature of the oxygen of the blast up to the required point for uniting with the elements thus dissociated, and fusing the next-lying particles which are to be acted upon. The result is that heat from some auxiliary source must be supplied to make up this deficiency, and unless this be done, the globules of sulphide will be blown cold, or, at best, only a roasting process will ensue. In the Manhès process, the air entering the tuyeres is heated by coming into contact with the molten mass, which has already been brought to a high temperature by the preliminary operation of melting the matte in a cupola before charging into the converter. This hot air then attacks the sulphides, and the burning of the sulphur and slagging off of the iron continues as long as there is any sulphide of iron in the vessel, or until the lining of the apparatus gives out. But the converter principle is not applicable to the smelting of low-grade ores because of its intermittent action, and all experiments reported up to the present time where converters have been used for pyritic smelting, have resulted in failure.

In pyritic smelting, as there are no masses of molten matter present from which the blast can take up sufficient heat so as not to chill the small globules of sulphide while acting upon them, it becomes necessary to give the blast this temperature before allowing it to enter the furnace.

There are various ways of accomplishing this. The blast can be heated in a hot-blast stove before entering the tuyeres, or it can be heated in the tuyeres themselves. In the former case, a costly and wasteful apparatus is employed, as the heat passing out through the chimneys, and radiated out through the walls, etc., causes an unnecessary expenditure of fuel for the purpose in hand. If a fire-brick stove be used (and these are the most efficient), its cost may exceed that of the entire balance of the plant: if a pipe-stove be employed, on account of the defects of such an apparatus, only a small portion of the calorific power of the fuel is utilized in heating the air passing through the pipes. By far the best method is to apply the heat (generated usually by gasifying some cheap fuel in a producer) directly to the end in view, by burning it in the tuyeres themselves. One of the advantages gained by applying the heat of the fuel direct to the blast is, that practically all of it may be made available and the expenditure for this purpose is therefore reduced to a minimum. Furthermore, when fuel is burned in the tuyeres, the products of combustion can, if desired, pass into the furnace, and mingling with the heated blast, modify its sharp action. Highly heated air is chemically very energetic, and unless some means be taken to restrain its intensity it is very apt to produce results exceeding those desired, oxidizing the monosulphides, not only to ferrous but even to ferric oxide. For this reason it is best to place it in the power of the furnaceman to be able to modify the action of the blast so as to adapt it to the work to be performed. This is readily brought about by varying the amount of fuel burned in the tuyeres, and allowing the products of this combustion to enter the furnace, in this way rendering the action of the blast intensely oxidizing, neutral, or reducing, at will. This is only possible when heat is applied directly to the blast entering the furnace.

The amount of fuel necessary for the direct heating of the blast is comparatively small, and is readily computed when the calorific power of the fuel, and the volume of the blast, are known. A relatively small amount of inferior fuel burned in the tuyeres is a very much less expensive method of heating the blast, than where a hot blast-stove is used; or where the blast is heated by coke or charcoal burned in the furnace. In any event, where raw sulphides are smelted in a blast-furnace, the blast must be heated in some way, for they will not fuse and produce matte and slag unless an auxiliary source of heat be provided. The prevailing custom (owing to the use of improperly constructed furnaces) is to heat the blast with coke charged into the furnace with the ore; but this is done mostly through ignorance of the true principles involved

in the operation, and often is forced upon the experimenter by an attempt to utilize apparatus already on hand. It is bad practice, and unfair to those who put their money into enterprises of this class.

Thirdly, as the charge column in a properly conducted pyritic smelting-furnace must of necessity be low, and as the heavy globules of molten sulphide drop past the tuyeres very rapidly, it follows that the time during which the blast can act upon them is very short. If, therefore, a weak blast (such a one as is usually employed in lead-smelting operations) be brought to bear upon these quickly-moving globules, its action is comparatively ineffective, and the molten globules escape with only a partial oxidation of their surfaces. For this reason it is necessary to use a higher pressure than that ordinarily employed in western blast-furnace practice. The molten sulphides must be broken up, in fact they must be sprayed and blown against the siliceous portions of the charge (held in suspension as it were) until a sufficient oxidation has taken place.

Care must be exercised that the volume of the blast is not too large, for (as has been shown in practice, and as will be apparent by submitting the matter to analysis by thermal calculations) if even a slight excess of air be blown into the furnace, the cooling effect of the surplus air is very marked. The furnace can even be blown cold by too large a volume of blast. To illustrate the effects of introducing increasing amounts of air into a pyritic smelting-furnace, let us take a formula which gives the maximum efficiency of any fuel burned in a blast-furnace, with a blast heated to 400° Cent., and then successively bring into such a formula increasing amounts of air.

Let $P_n = \frac{\leqslant ayj + 0{\cdot}2375\ tq.}{\leqslant pc - c_n} = T$ be such a formula, in which P_n, is the maximum temperature attainable before the tuyeres; a, calorific power of each element; y, weight in pounds of each element; t, temperature to which blast is heated; q, weight in pounds of air necessary for combustion; p, weight of each product of combustion; c, specific heat of each product of combustion; c_n, specific heat of the fuel; and 0·2375, specific heat of air.

Then we have in the case of iron monosulphide, when only the theoretical amount of oxygen necessary for the operation is introduced:—

$$T = \frac{1155 + 0{\cdot}237 \times 400 \times 2{\cdot}3523}{0{\cdot}6683 - 0{\cdot}1357} = 2{,}587° \text{ Cent.}$$

If we now add 50 per cent. of additional air, then

$$T = \frac{1155 + 0{\cdot}237 \times 400 \times 3{\cdot}5289}{0{\cdot}9471 - 0{\cdot}1357} = 1{,}835° \text{ Cent.},$$

and we see that the temperature is materially lowered.

If double the necessary quantity of air be introduced, then we find the value of T to be:—

$$T = \frac{1155 + 0{\cdot}237 \times 400 \times 4{\cdot}7046}{1{\cdot}2258 - 0{\cdot}1357} = 1{,}469^{\circ} \text{ Cent.},$$

which is scarcely a smelting temperature, and if three times the requisite amount of air be blown into such a furnace, then we have:—

$$T = \frac{1155 + 0{\cdot}237 \times 400 \times 7{\cdot}0569}{1{\cdot}7833 - 0{\cdot}1357} = 1{,}107^{\circ} \text{ Cent.},$$

which is equivalent to saying that the furnace will be blown cold. It is, therefore, clear that anyone who has been accustomed—as in lead or copper-smelting—to pump all the air into a furnace that it will take, will (especially if the blast be weak) cool off the sulphides immediately in front of the tuyeres without penetrating the charge far enough to oxidize those lying more towards the centre. The result of such an experiment will be that the experimenter will be obliged to resort to coke, or his furnace will be frozen-up in a very short space of time.

So, what is evidently wanted is pressure of blast, not volume, and therefore the tuyere-openings must be carefully adjusted to the needs of the furnace, so that just sufficient air for the requirements of the operation will pass through the tuyeres, and under sufficient pressure to reach the centre of the charge. When the furnace is properly managed the oxygen entering the tuyeres should be consumed to the extent that sulphur-fumes will distil off from the surface of the charge, and may be collected and further utilized.

Fourthly, to protect the workmen from the stifling gases given off by a pyritic furnace, and at the same time to provide for the regular charging of the ore and fluxes, the top of the furnace should be kept closed and a proper feeding-device provided. Such an apparatus has been designed which is automatic in its action (not requiring the presence of workmen on the top of the stack), and which distributes the various portions of the charge in the parts of the furnace where it is desired to place them. By keeping the easily-fusible sulphides to themselves and protected from the heat of the escaping gases as they descend into the smelting zone, and by placing the infusible portions of the charge so that they can be heated by the escaping gases and will retard the fumes and dust blown off, the working of the furnace is much more regular.

Concentration and Saving.

The degree of concentration effected in a pyritic smelting-furnace is in direct ratio to the amount of iron burned, hence to make a good con-

centration the monosulphide must be retained under the influence of the blast until the desired quantity of iron has been converted into oxide. For reasons already given, a high concentration cannot be expected where coke and sulphides are burned simultaneously, unless the matte is repeatedly passed through the furnace. Where this is done, however, a concentration of 10 into 1 is readily effected.

Where no coke is used there is no reason why any desired degree of concentration should not be reached, but to accomplish this, two smeltings are necessary. Assuming that, in order to make a slag which can be thrown away, a concentration of 5 into 1 is all that can be done with a given ore in a first smelting, then the first matte may be charged back into the same furnace, together with highly siliceous ores, and concentrated 5 into 1 a second time. One ton of the second matte then represents 25 tons of the original ore, and the concentration is therefore 25 into 1. The slag from this second concentration may sometimes contain too much valuable metal to throw away, but in such cases it may be put back into the furnace with a subsequent charge of raw ore, where it is of assistance in keeping the sulphide mass open.

A second treatment of the matte produced in the raw-ore smelting is not usually an additional expense, as would at first appear to be the case. If a furnace be rated at 150 tons of ore per diem of 24 hours, and 5 tons of raw ore are concentrated into 1 ton of matte, there are produced 30 tons of the latter every day, and in 4 days there will have been accumulated 120 tons of matte. Now this amount of matte will require about 30 tons of quartz to slag off the iron and concentrate it further, so if the plant consists of only one furnace, every fifth day can be set aside for matte-concentration. As very siliceous ores are best employed for concentration purposes, and as such ores always command a high smelting charge in the market, this secondary operation may, under favourable conditions, be even more remunerative than the raw-ore smelting itself. As the slag resulting from the concentration of the matte is put back into the raw-ore smelting, there is no danger of losing values from this source, and, therefore, a high-grade siliceous ore may be used for the purpose.

That concentration in a pyritic furnace can be carried to whatever point is desired, is seen when an effort is made to retain the monosulphide in the furnace instead of allowing it to escape as soon as formed. Under such conditions it will be wholly consumed, only slag resulting from the operation. This has been demonstrated repeatedly in an experimental manner, though of course the values contained in the original ore are then found in the slag.

As a usual thing, the further concentration is pushed, the higher will be the slag-assays: but by adopting a system of double smeltings as outlined above, the amount of values going into the slag is of little concern, for they are again recovered in the raw-ore smelting.

The percentage of saving effected in pyritic smelting depends upon several factors, prominent among which are, the composition of the furnace-charge, the amount of matte-fall, and the time given for the separation of the matte from the slag.

With regard to the matte-fall, if the saving of silver values is alone to be considered, a fair concentration may be made in an iron matte, provided the matte-fall is large enough. As this subject has been fully treated in standard metallurgical works (Messrs. Kerl, Percy, Plattner, etc.), it would be mere repetition of what has already been written to go into it here, and those desiring to inform themselves upon this point are referred to the above named authors.

When the aim of the process is to collect gold, an iron matte has not given satisfaction so far, as the affinity between gold and the sulphide of iron does not appear to be sufficiently great to cause a good concentration of the former in a matte composed of the latter. However, it has been found in practical work that if a small amount of copper be present in the charge the collection of the gold in the matte is very good. One per cent. of this metal has been found to give a saving of 95 per cent. of the gold contents of an ore, but 2, or even 3 per cent., are more desirable where they are attainable.

The amount of matte-fall necessary to effect a given saving must be determined experimentally in each instance, for a hard-and-fast rule cannot be laid down which will cover every case. Much depends upon the composition of the furnace-charge, the style of the furnace used, the skill of the man in charge of the operation, etc. A concentration of from 5 to 10 tons of ore into 1 ton of matte in one smelting is not difficult, and by making a double smelting, from 20 to 30 into 1 is attainable. Where copper is the principal valuable ingredient of an ore, the degree of concentration is governed by the richness of the ore, because in pyritic smelting it is not feasible to make a higher grade matte than in ordinary blast-furnace work. As far as reported to date, a 45 to 50 per cent. copper matte is as high as has been made, but this grade of matte is turned out regularly by at least one works. There seems to be, however, no reason why oxidation of the matte should not be continued in a pyritic furnace until white metal is produced, or even to black copper, but as far as known this has not yet been attempted.

There are two methods in vogue for separating matte from slag, some preferring to allow the matte to settle in the crucible of the furnace and to tap off the matte and slag separately; others choosing to let them both flow into an outside "receiver" and there separate. The outside receiver was adopted by copper-smelters to avoid the trouble caused by the formation of "sows" in the crucibles of their furnaces. Where a strongly reducing atmosphere is used in the shaft of a furnace, together with a basic charge, some of the iron is reduced to the metallic state and accumulates in the crucible in such masses as to often interfere with the operation of the furnace. Such an accumulation of metallic iron can even form in matting furnaces, for the monosulphide of iron has the property of dissolving more or less metallic iron at a high heat, which is precipitated at a lower one, so that sows may be built up in this way.

But with pyritic smelting-furnaces there is no danger from this source, as no metallic iron can maintain a separate existence in the oxidizing atmosphere of these furnaces, and so the necessity for a receiver is not apparent. It is well, however, to draw off the slag into a reverberatory furnace and to keep it there for a considerable time before discharging it, in order that any matte which may have become entangled in it shall have ample time to settle out. The values contained in slags, when matte is also present in the furnace, are usually present in the small particles of matte mixed through them, and it has been demonstrated repeatedly that if such slags are kept in a fairly liquid condition for a number of hours, the matte will sink to the bottom and leave the slag very clean. Attempts have been made to throw this entangled matte out of a slag by bringing the latter, while still quite liquid, into a rapidly revolving vessel, when it was found that the matte was thrown to the periphery, leaving the slag with only traces of valuable metals. But so far experimenters with such apparatus have failed to produce a machine which is satisfactory, the mechanical obstacles in the way being very great.

The specific gravity of a slag has much to do with the facility with which it can be separated from the matte, and therefore with the values contained in it. The specific gravity of a pure ferrous silicate is so near that of an iron matte, that the two separate with difficulty unless they are kept very liquid for a long time under conditions favourable to their separating. On the other hand, a complex slag, consisting of a mixture of the silicates of the lighter bases with silicate of ferrous oxide, rises readily from most mattes. Hence it is always advisable to use limerock, or its equivalent, in the furnace-charge when it is economically possible.

When experience has been acquired in the operation of a pyritic fur-

nace, and with the necessary amount of matte-fall, and when time is given the matte to separate from the slag, a saving of from 95 to 98 per cent. of the gold, silver and copper contained in a pyritic ore can be realized in a properly constructed furnace.

Mr. G. B. Reynolds (London) wrote that the interest of Mr. Austin's already interesting paper would be enhanced if he would give some figures showing the composition of the slags made in pyritic smelting. Dr. Carpenter, at Deadwood, used magnesian limestone as the only flux in smelting siliceous gold ores* making presumably a slag such as would be made in an iron blast-furnace. Further, could the author give any information as to the losses by volatilization in pyritic smelting, as it would seem that with the small height of the charge, and the necessarily "hot top," the losses must be large, though recoverable to a certain extent in the flues.

Prof. H. Louis (Newcastle-upon-Tyne) wrote that Mr. Austin's paper on his especial subject of pyritic smelting deserved respectful study, but it would have been of greater value had he given more information concerning the practical execution of the process. It is a curious fact that amongst all the really considerable mass of literature that the last few years have produced on this subject, the majority of the writers, all, too, advocates of pyritic smelting, confine themselves to generalities and omit the facts. It would, for instance, be infinitely more satisfactory if Mr. Austin would favour us with plans and dimensions of the furnaces which he has found most successful in treating a definite kind of ore. He here states that he uses a furnace with an inner cylinder: it has, however, been stated by others that Mr. Austin had some time ago discarded this tube, and it would be interesting to know whether he had reverted to it, and if so, under what conditions. Other pyritic smelters claim that they obtain perfectly satisfactory results without the use of such a tube. Another point of importance upon which information is needed is the result practically obtained by pyritic smelting processes. If Mr. Austin had favoured the members with the actual results of, say, a 12 months' campaign, they would be in a position to judge of the value of the process which he advocates. Perhaps he will kindly give the figures for a 6 months' or 12 months' run, the amount of ore treated, the quantity and nature of the fluxes used, the quantity of coke charged into

* *Engineering and Mining Journal* (New York), 1893, vol. lv., page 28.

the furnace, the quantity and nature of fuel consumed in heating the blast, and in producing the blast, temperature, volume and pressure of air injected, the quantity of matte produced, together with assays of the ore, matte and slag. If the members had such a table before them, they would at any rate be able to judge of the efficiency of the process, and if he would add the annual wages bill and repair account, they could readily arrive at its economic value also. So far, it had been impossible to obtain any records of results obtained over a period of more than a few days, and the doubt, whether true pyritic smelting (that is to say, the smelting of ore absolutely without the addition of any carbonaceous fuel in the furnace) has ever been carried on anywhere continuously for more than a few days is quite justifiable. It is to such an authority as Mr. Austin that members are entitled to look in order to have that doubt set at rest, and until he or someone of equal experience will enlighten members as to the technical and economic results obtained in a lengthy campaign, it will be necessary to look upon pyritic smelting as a subject of theoretical speculation that has not yet emerged from the purely experimental stage.

DISCUSSION ON MR. HALLIMOND'S "NOTES ON THE COAL-SEAMS OF THE TRANSVAAL."*

Mr. Frank Simon (Johannesburg) wrote that Mr. Hallimond stated that dust was useless, but his opinion as to the coking qualities of Middelburg coal would have been useful, as some mines turn out a good coke. Does Mr. Hallimond claim that the appliances at the Rand collieries effect a saving of 1s. per ton in comparison with a similar well equipped colliery in the Transvaal? He (Mr. Simon) understood that Mr. Hallimond claimed a saving of 3½d. per ton in banking-out and tipping, and further, "the saving by the use of distributing-shoots, as adopted at the Rand collieries, is about 8½d. per ton on the present output," which together equal a saving of 1s. per ton. Mr. Hallimond did not state how and in what manner the shoots at the Rand colliery differed from those in use at other collieries, neither did he point out the new features in his method of dumping. A shilling per ton saving in surface-cost is a large item in this or in any other country, and it would be instructive to know how it was effected by a comparison between the costs at the Rand colliery and, say, the Cassel colliery.

The meeting was then closed.

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* *Trans. Fed. Inst.*, vol. xiii., page 372.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

STUDENTS' MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 18TH, 1897.

MR. H. W. MIDDLETON IN THE CHAIR.

Mr. ANDREW BURT read the following paper on "The Methods of Working Minerals, Secondary Haulage, and Ventilation in Fifeshire":—

THE METHODS OF WORKING MINERALS, SECONDARY HAULAGE, AND VENTILATION IN FIFESHIRE.

BY ANDREW BURT.

We find, on looking over the annals of coal-mining, that the Fifeshire coal-field plays a very prominent part in that industry, it being among the first of the coal-fields of the kingdom to be worked. Coal was worked in this district as far back as the beginning of the thirteenth century, and probably before that date.

The monks of Dunfermline held various leases for the working of coal and other minerals in the neighbourhood of that town. One of these leases is dated 1291, when a grant was made by William de Oberwill of Pittencrieff to the abbot and convent of Dunfermline to work coal, etc., on that estate. Some of the old workings (or what were supposed to be old coal-mines) were found recently in the vicinity of the town during excavations which were being made for building purposes.

At this early period, the colliers were in a state of slavery (servitude) which continued more or less up to the seventeenth century. In 1600 (or about that time), an Act of the Scottish Parliament was passed which empowered the owners of the collieries, etc., to apprehend all vagabonds and sturdy beggars and set them to work. The colliers were then reckoned as part of the plant or estate, and were bought or sold along with the same when it happened to change hands. Tradition has it, that the estate of Halbeath, along with the colliery (the working of which

colliery forms the substance of this paper), the colliers and their families, were sold at one time for £300. This state of servitude lasted till about 1791, when the colliers received their liberty. The anniversary of this event was commemorated from year to year, and was a day of general rejoicing. The whole population of the village turned out and formed into procession, headed by a band, and paraded round the district. Some of the men were mounted on horses borrowed from the adjacent farms. This custom, however, has died out.

Coal is worked in Fifeshire both above and below the Millstone Grit, or from the true Coal-measures and the Carboniferous measures (Appendix A). The coal-bearing strata of these two measures are nearly 7,000 feet in thickness. In the eastern district of Fifeshire, the upper portion or true Coal-measures is being worked, while in the western district these upper seams have been denuded, and the lower portions or Carboniferous measures are left. The lowest workable seam, the Dunfermline Splint coal-seam, is worked extensively in the western district of the field. There is a thin seam of coal below the Dunfermline Splint, but it is of no commercial value and is not worked.

During the earlier operations, the coal was only worked opencast at the outcrop or for a very limited distance under cover, as no machinery of any kind was available at that time. In course of time, however, the workings began to extend under the surface, and to support the surface which was causing a good deal of trouble by its subsidence, small pillars of coal were left. These pillars, however, were very small and were soon crushed, and the works frequently lost for the time being. Small pits were then sunk and ladders fixed in them. The coal was carried up these ladders by women and girls with baskets or creels, somewhat similar to those used by fishwives. One of these baskets and a pair of boots were found in an old mine a few miles south of Edinburgh quite recently. The water was drained from these pits by small adit-levels. This system was called the pit-and-adit method of working coal, and some of these adit-levels are still in daily use in this district.

With the extension of the workings, the quantity of water in the workings also increased, and a machine termed the Egyptian wheel or chain of buckets was put forward as a contrivance to cope with this obstruction. One of the first coal-owners to use this machine in Scotland was Sir George Bruce at his Culross colliery in this district, and by the aid of this machine he was enabled to extend the workings of his mines for a distance of about 1 mile under the Firth of Forth. King James

VI., while hunting in this district, paid a visit to this colliery in the year 1617. He went down one shaft which was on the shore, and after going through the workings he came up a shaft which was sunk on an island about ½ mile out in the Firth.

Women and girls were employed below ground in the collieries near to the town of Dunfermline up till about the year 1849; and they are still employed on the pit-banks.

The seams of coal at present worked vary in thickness from 18 inches to about 20 feet. The system of working adopted is longwall with its various modifications, this being the system in vogue at all the collieries in the Fifeshire coal-field. One of H.M. inspectors of mines, Mr. Ralph Moore (now deceased), while speaking at a meeting of the members of the Mining Institute of Scotland, said that, "he thought they worked longwall in Fife better than at any place he had seen it in the eastern district, and if anyone had not seen a Fife longwall working, he would advise them to see it." The stoop-and-room system is also adopted, but in very few cases, only a small section here and there being so wrought where special precautions as regards surface-damages to buildings or other such like causes prevent the use of the longwall method.

Stoop-and-room Working.—In working by the stoop-and-room system, after the shaft or bottom pillars have been formed and main headings and levels set off, stoops of from 90 to 150 feet square or of a rectangular shape are formed. The roads which are driven at right angles to the cleavage of the seam are easier to work, and larger coal is got out of them than is the case with the roads which run parallel to the cleavage. These roads are driven from 12 to 14 feet wide, whereas the roads which run parallel to the cleavage are only made 7 to 9 feet wide. There is a lot of cutting in the roads which run parallel to the cleavage of the coal, as they are harder and more difficult to work, more dross is got out of them, and less round coal. They are accordingly very often driven farther apart than the other roads, and so make the stoop or pillar of rectangular form. It is customary to have each end or end-road blinded by the next stoop; that is, instead of the ends running in a continuous straight line as is the case with the level roads, each end is opposite to the next and following stoop similar to the jointing in a brick wall. This method does not allow of a large area of the roof being left unsupported, and so assists in the support of the roof. This working is termed working the whole or first working, and may be driven right out to the boundary of the field before the second working, or working of the broken, is begun. This

method is sometimes practised, but it is more common to follow up the first with the second working before the roof gets time to settle down. Where the first is immediately followed by the second working more round coal is produced than in the other method, as the stoops are not so much crushed and broken as when the roof and strata above have settled down.

In taking out the stoops, a road is driven right through the stoop both ways, cutting the stoop into four small stoops ; then each of these small stoops is taken out in turn. They may be taken out by cutting a slice off the side of the stoop, and also off the side adjacent to this one, and this is followed up by other slices ; but this method is not commonly adopted unless the stoops are small.

Longwall Working.—The longwall system, in which all the coal is taken out in one operation, is the one most commonly adopted, being practically used for all of the seams of coal which are worked in the district. From the main levels, headings are driven at distances of 210 to 240 feet apart, and from these headings the ordinary or branch roads are branched off level course. After the first heading has advanced a certain distance, the second heading which is 210 or 240 feet farther inbye the level is set up. This heading, as it advances, cuts off the branch roads from the first heading as they are driven forward. The branch roads from this second heading are in turn cut off by the next heading as it advances, and so on. The distance between these branch roads is about 45 feet, and the width of the roads about 7 feet. The face or wall of coal for each road is therefore about 45 feet, the same length as the distance between the branch roads. The face may be all to the rise side of the road, or may be partly on each side according to the inclination of the seam. In this district, it varies from horizontal to about 45 degrees.

Coal-cutting machinery has been tried on one or two occasions, but did not work very satisfactorily, and has now been entirely dispensed with. A Stanley heading-machine is working at one of the collieries.

The holing is made in the bottom, or in the middle of the seam if there happens to be a rib of daugh or fire-clay running through the coal. The small coal, when not fit to be sent to the surface owing to the mixture of clay, etc., which may be in it, is used to pack the walls and buildings. Stones for the walls or buildings are got by the brushing of the roof or overlying strata, or sometimes the floor, to get sufficient height for the drawing-roads.

There are one or two modifications of this system of working. In the Chemiss coal-seam, about 9 feet thick or more, and the Dysart Main coal-seam, about 20 feet thick in the eastern part of the county, and the Jersey coal-seam, from 10 to 15 feet thick, and the Lochgelly Splint and Parrot coal-seam, varying up to about 18 feet thick in the western part of the county. In these seams, the coal is worked in two operations, the lower portion of the seam being worked first and the upper portion afterwards.

There are one or two slight differences in the working of these seams peculiar to the colliery in which they are worked, but the general mode of working is much about the same. At Kingseat colliery, where the Jersey coal-seam (Appendix B) is being worked, and also the Lochgelly Splint and Parrot seam (Appendix C), the mode of working the first-named seam, which was adopted a few years ago, was as follows :—A section was commenced by driving a heading in the bottom coal or first working to the rise, and from this heading the ordinary roads were branched off level-course. These roads are from 36 to 45 feet apart and about 7 feet wide. To get sufficient height for the working-roads, the stone between the two parts of the seam is taken down, and sometimes part of the top coal also. The stone thus got is used for building purposes. This stone is of a varying thickness, and sometimes the whole of the top coal requires to be taken down so as to get sufficient height for the drawing roads. Roadside buildings are put in, these are 2½ feet or so across the face and consist partly of the stone got from the roof and partly of prepared pieces of wood 2½ feet long. The buildings are well packed with the dross coal which is made in the workings, or any daugh or fire-clay which may be thus got. No open cundies are left in the waste. A rib of fire-clay runs through the lower part of the seam and the holing is made in it. The thickness or length of the holing is regulated by the amount of stuff required to fill the waste and pack the buildings. When the weight on the coal-face is not very keen, the holing is made heavier. Rances or gibs are used very freely to keep up the face during holing operations. These are props or pieces of props varying in length up to 5 feet long. Figs. 1, 2, 3, and 4 (Plate VI.) are a general plan, a sketch of a working-place in the first working, section of coal-face, and the method of rancing respectively.

The second heading, which is driven as in the ordinary method of longwall and cutting off the branch roads as they are driven forward, is where the second working begins. After the second heading has cut off all the roads in the first heading, the working of the top coal

is commenced (Fig. 1, Plate VI.). This begins at the top end or innermost part of the heading, and is worked outwards. The first place is driven a few feet before the next place is started, and so on, each place being about, say, 10 feet in advance of its neighbour. The coal worked in this operation is taken to the lyes (stations) by the roads which were made in the first working, and as the faces move backwards the rails are lifted to be used over again in the next workings. Before this working has got back to the first heading, the roads begin to get very low and also narrow, and in order to get stones and material to pack and build the places, the roof is sometimes brushed a second time. If the material for this purpose happens to be a little scarce, open spaces are left in the old roads, but never in the waste. The holing of this second working is made in the waste of the first working. Figs. 5, 6, and 7 (Plate VI.) show the plan and sections of the working-face in this second working.

Some of the advantages of this longwall system are:—The whole available coal is wrought, the ventilation of the working-places is much easier than in the stoop-and-room system, and it is as safe, as economical, and as efficient as any of the other methods of working thick seams of mineral.

In one or two cases, the second working, instead of coming back, is worked forward about 60 feet or so behind the first working. The holing being done as in the previous case, viz., for the first working in the seam, and for the second working in the waste of the first working. Care, however, must be taken in this case to have the second working at a regular distance behind the first working. If it is too far behind the first working, the top portion is very much crushed, and the waste is too firm to hole in: and if it is too close to the first working the strata are not quite settled down, and, consequently, very unsafe to work. The coal is more difficult to work, and after it has been worked it is not so good as when kept at a regular distance behind the first working.

Gob-fires by spontaneous combustion are of frequent occurrence in the eastern district of the coal-field, but no such occurrence has happened in this district to the knowledge of the writer. A good means of preventing fire is to keep the area of the sections or districts as small as possible so as to get all the coal out quickly, and when the section is finished seal up the old roads and keep the air from getting into the gob. Fire readily takes place where the waste is not well stowed, and also near the rib-side.

In the working of the Splint and Parrot seam at the Kingseat

colliery, the lower portion is worked first: material is taken from the roof to give height to the drawing-roads, and to pack and build the roadside buildings. The remaining strata are allowed to fall, and the upper portion is worked on the top of these old roads, but sometimes new roads require to be made. The distance between these two workings may be as much as 300 feet.

Haulage.—The haulage may be in stages, the first being from the faces to the collecting-stations or sidings, and the second from thence to the pit-bottom. We will, however, only describe the first stage of operations, that is from the faces to the collecting-sidings or engine-siding. This haulage may be effected in various ways by men, boys, horses, ponies, etc., and where the inclination of the strata permits, by self-acting inclines. It may be done by one of these or by all. At the Hallbeath colliery, where the inclination varies from horizontal to about 45 degrees the headings are all driven to the rise.

This system permits of an arrangement which is universally adopted throughout Fife, termed the cut-chain arrangement, which forms one of the principal features of a Fife longwall working, and the writer is led to believe it was this arrangement partly which caused the remarks by H.M. inspector of mines, which he has already mentioned. It is worked as follows:—

(1) A wheel *A* is placed at the top of the heading, and is fitted up in the same manner as in an ordinary self-acting incline. The chain passes round the wheel, and down the heading to the foot of same. At every branch road or cut, as it is termed, a disconnecting-hook *B* is placed in the chain, so that the upper portion of the chain can be disconnected when required (Fig. 8, Plate VI.). Between the rails and across the breadth of the road deals or planks are fixed, so that a hutch can run right across the two roads of the incline. These planks or deals are fixed in so as not to interfere with the hutches coming down from the roads above. At the top of this platform is placed a small grooved wheel *C* and fixed firm to the platform (Fig. 9, Plate VI.). Whenever a hutch is required to be run down the incline from any of these cuts, the top portion of the chain is disconnected. The end of the lower portion of the chain is passed round the small wheel *C* at the top of the platform, and then fastened to the hutch. The hutch is then run down as in the ordinary incline. To brake this wheel while running, a small piece of wood about 18 inches long, of the shape of a pick shaft, is used, being pressed down on the top of the wheel while braking. In

working the top branch, the wheel *A* at the top of the heading is used, and acts in the same way as an ordinary incline.

The second arrangement is as follows :—A wheel *A* is fitted up at the top of the heading as in the first arrangement, but no wheels are used at the branch roads : the wheel at the top being made use of for the working of all the branches. The chain in this case, in addition to the length of the incline, must be as long as from the top of the incline down to the first branch. The chain will thus be twice the length of incline less the small distance from the level road to the first branch, and it is cut at every branch *B* (Fig. 10, Plate VI.). In the working of this arrangement, two hutches must be run from each branch every time, in order to get the cuts into their proper positions for the other branches to be able to work the same. The platforms at the branch roads are the same as in the previous arrangement, and, where the inclination is steep, the pavement is cut out and the platform made level ; rails are then laid across the platform to allow the hutches to run across. These rails are not fastened down, but laid so that they may be lifted out at convenience when a branch road is being worked. In order to run a hutch from one of the branches, the lower portion of the short side of the chain is disconnected at the cut *B*. The upper portion is then fastened to the hutch and the hutch set away. The brake of the wheel at the top is operated by a wire attached to the brake-handle and led down the whole length of the incline. When the first hutch is run down, the empty hutch comes up the side away from the branch road. The second hutch is therefore run right across the incline to the farthest side, fastened to the chain and run down. The chain will then be in the position in which it was before running down the hutches. The drawer must then connect the two portions of chain again, so that the other branches may be allowed to make use of the incline. Care must be taken that the portions of the chain are all connected before the drawer leaves them.

The chain must be lifted from one side of the incline to the other side every time a hutch is run in the first arrangement, as the hutches are commonly only run down one side ; one hutch being taken from each branch at a time. Less chain is used in the first arrangement, but more wheels. Both systems are common in the district.

The hutches may be drawn from the faces to these inclines by the miners themselves, or it may be done by contract. Some managers think that by getting the miners to draw the coal to these inclines and run them themselves less time is wasted. When such is the case, there are two men and sometimes three men in each face, one being employed filling

the coal and drawing it, while the other is kept constantly at the face. In the other case, the coal is drawn from the face, after being filled by the miner, to the inclines, run down the inclines and drawn from the foot of the inclines to the engine-siding by contract: the contractor being paid by the score or by the ton.

The following is given as an example of this contract system in a section of the Jersey seam:—From the coal-face to the cut-chain brae two men are employed drawing; from the bottom of the cut-chain brae to the siding of the main haulage-road one boy is employed; the wages for one fortnight are £7 10s.; adding to this amount the keep and harness, etc., for one pony, £1 10s., making a total cost of £9. The total tonnage drawn from this section was 628·15 tons of coal and dross, showing a cost of 3·43d. per ton. The average distance along which each ton of coal was drawn was about 480 to 510 feet. The upkeep of chains and wheels, and veterinary attendance is not included. The cost of horse-keep is higher than the average allowance for keep of horses. The cost of haulage by men and horses is sometimes considerably higher than the above cost.

Another example of drawing in the same pits in the Dunfermline Splint seam is as follows:—From the coal-face down two cut-chain braes, six men and one boy are employed, the wages earned per fortnight being £19 17s. 1d., adding cost of keep of pony £1 10s., the total cost being £21 7s. 1d. The total quantity drawn from this section was 756·8 tons of coal and dross, making a cost of 6·77d per ton. The average distance per ton of coal drawn was about 900 feet to the engine-siding.

In one or two cases, where the drawing-road at places and for short distances in the same is rather steep for hand-putting yet not quite steep enough for a self-acting incline, an arrangement on the same principle as the incline is used. At the side of the drawing-road, another road of a narrow gauge is laid down the whole length of the road where the steepness occurs. A small loaded bogie is put on this road. A wheel is fixed at the top of the steep part of the road, and a chain is passed round this wheel and fastened to the bogie. When the drawer comes to this part of the road with his loaded hutch, he fastens the loose end of the chain to his hutch and the loaded hutch in going down this small incline draws up the bogie. The loaded hutch may not of itself be able to draw up the bogie, and the drawer has then to push the loaded hutch down. After reaching the bottom, the chain is made fast to some catch so as to prevent the bogie from running back. When the drawer returns with the empty hutch, he fastens the chain to it, and the drawer is thus assisted by the counterbalance to the top of the steepness. By inverting the arrange-

ment and making the begin a little heavier it can be used to assist in drawing the loaded hutch up a small dook where the drawer is not able to do the same himself.

Ventilation.—By ventilation, we mean the removal of all dangerous and deleterious gases from the mine, or the rendering of such gases harmless, so as to keep the mine in a safe and healthy condition. In accordance with the Coal Mines Regulation Act, an adequate amount of ventilation must be constantly produced, so that the working-places and travelling roads to and from these places may be in a fit state for working therein. The quantity of air passing in the various splits and airways must be measured every month, and a note of the same entered in a book kept for such purpose at the mine. The ventilation must also be inspected every morning before the miners begin work, and such inspection noted in the aforesaid book. The airways must be not less than 4 feet high and 4 feet wide and must always be in a fit state for travelling therein.

The gases generally found in mines which are of a dangerous nature are light carburetted hydrogen (fire-damp), sulphuretted hydrogen, carbon dioxide or carbonic acid gas, and carbon monoxide. These are the chief gases met with which endanger life and property. In this district, there is practically no fire-damp or carbon monoxide. There is abundance of carbon dioxide or carbonic acid generally called choke-damp or black-damp.

Sulphuretted hydrogen is very seldom found. On one occasion, the writer came in contact with a small trace at the side of a roadway where some small coal was lying and the pyrites in the same was being decomposed by the water running at the side of the roadway. On the small coal being disturbed, the gas was soon dispelled.

Choke-damp or black-damp is given off in great quantities from the workings in this district, and being very heavy it lies near to the floor of the mine and is not easily shifted. In one instance, when a section of one of the seams in the Kingsett pits had been flooded with water and then had not been worked for a few weeks, it was found that the section was full of choke-damp, and it had accumulated to such an extent that some weeks elapsed before it was all got out.

In ventilating in this district, the air is first conducted to the dip-workings and from thence to the rise portions.

The return portions of the airways are generally of smaller diameter or sectional area than the intakes, and this causes the current to travel at a high velocity. A slow current of air would only flow over the top of the choke-

damp and leave it lying on the floor, and by making the return airways of small area, the stronger current is able to push this gas along and so get rid of it.

The ventilation at all the collieries in this district is produced by fans of the Waddle, Guibal, or Schiele types, practically no furnaces being in operation. At the Kingseat colliery, a Guibal exhausting fan, 24 feet in diameter by 8 feet broad, is employed to ventilate three shafts, and a Schiele exhausting fan, 40 inches in diameter, is used to ventilate one shaft. The following is a note of the various quantities produced and passing in the various airways :—

	No. of Split.	Smallest Area Square Feet.	Length of Airway. Feet.	Quantity of Air. Cubic Feet per Minute.
No. 1 shaft ...	1	24	8,310	7,800
	2	22	8,985	6,500
	3	16	3,000	2,000
No. 2 shaft ...	1	28	12,894	7,100
	2	24	8,400	3,900
	3	20	6,150	2,800
No. 3 shaft ...	1	25	4,410	6,500
	2	24	3,390	5,300
No. 4 shaft ...	1	20	4,300	2,800

The total quantity circulated by the Guibal fan being 41,900 cubic feet per minute, and by the Schiele fan 2,800 cubic feet per minute.

In the ventilation of the Jersey seam, the air is conducted up the heading and split at the top, one half of the current going round the faces of the first working and the other half round the faces of the second working (Fig. 1, Plate VI.). Where the second line of faces are following up behind the first working, a regulator is sometimes put in halfway between the faces of the first working and the faces of the second working, and so causes part of the current to be passed round each set of faces.

References to Plate VI.

Fig. 1 is a plan of workings in the Jersey seam.

Fig. 2 is a plan of the face of the first working, showing the pack-walls and road.

Fig. 3 is a section of the face of the first working, with the strata comprising the same.

Fig. 4 is a section of a roadway in the first working.

Fig. 5 is a plan of the face of the second working.

Figs. 6 and 7 are sections of the face of the second working.

Fig. 8 is a plan of a cut-chain brae. *C* is a small wheel for working the cuts, and *B* the cut hook or disconnecting-link.

Fig. 9 shows the form of wheel used at the branch-roads.

Fig. 10 is a plan of a cut-chain brae as used in the second arrangement.

Fig. 11 shows the cut hook or disconnecting-link.

Fig. 12 is a section of a platform at a branch road.

APPENDIX A.—Section of Strata in the Western District of Fifeshire below the Millstone Grit.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth Below Millstone Grit. Ft.	In.
	Millstone Grit, composed principally of rough sandstones ...	773	0		
	Levenseat or Castlecary Limestone —				
1	Limestone ...	7	0	7	0
2	Shale	7	0	14	0
3	Limestone ...	2	0	16	0
4	Shale	6	0	22	0
5	**COAL**, in bands and shales ...	3	0	25	0
6	Sandstone	5	0	30	0
7	Shale	4	0	34	0
8	Sandstone	64	0	98	0
9	Shale	3	0	101	0
10	Sandstone	2	0	103	0
11	Shale	3	0	106	0
12	**COAL**	0	4	106	4
13	Sandstone and bands	6	0	112	4
14	Shale	6	2	118	6
15	**COAL**	0	6	119	0
16	Fireclay	6	3	125	3
17	Shale	4	6	129	9
18	Sandstone	4	0	133	9
19	Shale and bands ...	5	6	139	3
20	Shale	2	0	141	3
21	**COAL**	0	2	141	5
22	Sandstone ...	9	10	151	3
23	Shale	2	11	154	2
24	**COAL**	0	10	155	0
25	Shale	3	0	158	0
26	Sandstone	2	6	160	6
27	Shale	6	0	166	6
28	Sandstone	20	0	186	6
29	**COAL**	0	4	186	10
30	Shale and bands, with ironstone-nodules	6	0	192	10
31	**COAL**	0	4	193	2
32	Shale	0	9	193	11
33	**COAL** ...	0	3	194	2
34	Shale	0	9	194	11
35	**COAL**	0	4	195	3
36	Shale	1	0	196	3
37	Sandstone	7	10	204	1
38	Shale	4	9	208	10
39	Sandstone and bands	3	0	211	10
40	Shale	3	0	214	10
41	Bituminous shale ...	10	6	225	4
42	Bands	4	2	229	6
43	Fireclay	2	0	231	6
44	**COAL**	0	6	232	0
45	Shale	2	0	234	0
46	Sandstone	6	6	240	6
47	**COAL** ...	0	4	240	10
48	Bands and shale ...	17	0	257	10
49	Sandstone	38	0	295	10
50	Alum shale... ...	17	3	313	1
	Gair or Calmy Limestone —				
51	Limestone ...	0	8	313	9
52	Shale	0	7	314	4
53	Limestone ...	1	8	316	0
54	Alum shale	8	0	324	0
55	Sandstone	4	9	328	9
56	Bands and shale ...	19	0	347	9
57	Sandstone	11	0	358	9
58	Bands and shale ...	14	0	372	9
59	Shale	22	0	394	9
60	Shale and bands ...	22	6	417	3
61	Bands and sandstone	88	11	506	2
	Capledrae Parrot Coal-seam—				
62	**COAL**	4	4	510	6
63	Fireclay	4	0	514	6
64	Oil-shale	2	6	517	0
65	Fireclay and faikes	30	7	547	7
66	**COAL**	2	5	550	0
67	Faikey fireclay ...	15	0	565	0
68	Blaes	2	0	567	0
69	Blackband ironstone	0	9	567	9
70	Fireclay	0	4	568	1
71	Blackband ironstone	0	4	568	5
72	Fireclay	0	6	568	11
73	Faikey sandstone ...	25	1	594	0
74	**COAL**	1	0	595	0
75	Bands and sandstone	25	0	620	0
76	**COAL**	1	0	621	0
77	Sandstone	34	2	655	2
78	**COAL**	0	10	656	0
79	Sandstone ..	181	0	837	0
80	**COAL** ...	1	0	838	0
81	Faikes and fireclay	11	10	849	10
82	**COAL**, *Lochore Parrot Coal-seam* ..	2	2	852	0
83	Faikes and sandstone	18	0	870	0
84	**COAL**, *Bowersbank Splint Coal-seam*	3	0	873	0
85	Sandstone with thin *coal-seams* ...	46	0	919	0
86	Sandstone	93	6	1,012	6
87	Faikes	15	3	1,027	9
88	Limestone, *Index* ...	2	3	1,030	0

APPENDIX A.—*Continued.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth Below Millstone Grit. Ft.	In.
89	Sandstone	31	9	1,061	9
90	Fireclay with balls	11	6	1,073	3
91	Sandstone	17	6	1,090	9
	Comrie and Balbardie Coal-seam—				
92	**COAL**, rough ...	1	4	1,092	1
93	**COAL**, parrot ...	0	9	1,092	10
94	Blackband ironstone	0	8	1,093	6
95	Blaes	1	0	1,094	6
96	Faikes and sandstone	40	6	1,135	0
97	**COAL**, *Blairhall Coal-seam* ...	4	0	1,139	3
98	Sandstone	24	3	1,163	0
99	**COAL**, *Blairhall Coal-seam* ...	4	3	1,167	6
100	Sandstone and faikes	9	6	1,177	0
101	**COAL**, *Soft Smithy Coal-seam* ...	3	0	1,180	0
102	Sandstone	34	0	1,214	0
103	Fireclay with balls	4	9	1,218	9
104	Ironstone, *Lochgelly Blackband* ...	2	3	1,221	0
105	Fireclay and bands	10	0	1,231	0
106	**COAL**	0	3	1,231	3
107	Blaes and bands ...	17	6	1,248	9
108	Sandstone	10	9	1,259	6
109	Blaes and bands ...	14	3	1,273	9
110	**COAL**	0	6	1,274	3
111	Bands and freestone	61	6	1,335	9
112	**COAL**, *Little Splint Coal-seam* ...	4	3	1,340	0
113	Bands	5	0	1,345	0
114	Freestone	4	9	1,349	9
115	Bands	5	11	1,355	8
116	**COAL**, *Rough Coal-seam*	3	4	1,359	0
117	Bands	11	6	1,370	6
118	**COAL**, *Main Coal-seam*	3	0	1,373	6
119	Fireclay	4	2	1,377	8
120	**COAL**	1	4	1,379	0
121	Freestone	2	0	1,381	0
	Jersey Coal-seam—				
122	Blaes and bands	9	6	1,390	6
123	**COAL**	2	4	1,392	10
124	Blaes and bands	1	0	1,393	10
125	**COAL**	3	7	1,397	5
126	Fireclay ...	2	1	1,399	6
127	**COAL**	3	6	1,403	0
128	Blaes	0	6	1,403	6
129	Fireclay	1	3	1,404	9
130	Bands	9	6	1,414	3
131	Blaes	2	0	1,416	3
132	**COAL**, *Swallowdrum Coal-seam* ...	4	9	1,421	0
133	Bands	1	10	1,422	10
134	Fireclay	3	9	1,426	7
135	Bands	15	3	1,441	10
136	Fireclay	2	6	1,444	4
137	Bands	0	9	1,445	1
138	Fireclay	2	10	1,447	11
139	Bands	12	9	1,460	8
140	**COAL** and blaes ...	1	9	1,462	5
141	Bands and blaes ...	8	7	1,471	0
142	**COAL**, *Duddy Davie Coal-seam* ...	3	0	1,474	0
143	Blaes	2	3	1,476	3
144	Fireclay	1	0	1,477	3
145	Bands	3	10	1,481	1
146	Freestone	14	0	1,495	1
147	Fireclay	1	5	1,496	6
148	**COAL**, *Lochgelly Splint Coal-seam*	6	0	1,502	6
149	Blaes	4	0	1,506	6
150	Freestone	21	9	1,528	3
151	Blaes	2	3	1,530	6
152	**COAL**, *Lochgelly Parrot Coal-seam*	3	6	1,534	0
153	Grey bands... ...	8	0	1,542	0
154	Sandstone	20	0	1,562	0
155	Blaes and grey bands	37	0	1,599	0
156	Sandstone	2	9	1,601	9
157	Blaes	14	6	1,616	3
158	**COAL**, *Glassee Coal-seam*	2	9	1,619	0
159	Fireclay and blaes	5	0	1,624	0
160	Bands	5	9	1,629	9
161	Sandstone	59	0	1,688	9
162	Bands and blaes ...	21	2	1,709	11
163	Ironstone	0	4	1,710	3
164	**COAL**, *Mynheer Coal-seam* ...	3	3	1,713	6
165	Sandstone	12	0	1,725	6
166	Blaes	13	0	1,738	6
167	**COAL**	0	6	1,739	0
168	Fireclay	1	0	1,740	0
169	**COAL**	2	0	1,742	0
170	Bands	13	6	1,755	6
171	Sandstone	4	6	1,760	0
172	Blaes	1	0	1,761	0
173	Sandstone	4	0	1,765	0
174	Bands and blaes ...	12	4	1,777	4
175	**COAL**, *Five Feet Coal-seam* ...	4	8	1,782	0
176	Sandstone	2	0	1,784	0
177	Bands, with ironstone balls ...	54	6	1,838	6
178	Sandstone	39	0	1,877	6
179	Dark bands ...	1	9	1,879	3
180	**COAL**, *Dunfermline Splint Coal-seam*	3	9	1,883	0
181	Sandstone	14	0	1,897	0
182	Blaes	8	0	1,905	0
183	Freestone	5	6	1,910	6
184	Freestone with blaes	20	0	1,930	6
185	Blaes	20	3	1,950	9
186	**COAL**, *Stinking Coal-seam* ...	1	3	1,952	0
187	Sandstone and blaes	128	0	2,080	0
188	Limestone, *Hosie Limestone* ...	3	0	2,083	0

APPENDIX B. Section of the Jersey Coal-seam.

	Ft.	In.	Ft.	In.
Roof—				
Sandstone	8	8		
			8	8
Second Working -				
Blaes	0	4		
COAL	2	4		
Stone	0	2		
COAL	0	5		
			3	3
Bands—Fire-clay	1	4		
			1	4
First Working -				
Blaes and bands ...	2	6		
COAL	2	2		
Fire-clay	0	11		
			5	7
Floor -				
Sandstone	12	4		
			12	4

APPENDIX C.—Section of the Lochgelly Splint and Parrot Coal-seam.

	Ft.	In.	Ft.	In.
Roof - Blaes .		—		
Second Working—				
COAL	1	6		
Coaly strains ...	0	5		
Faikey blaes	0	11		
Coaly blaes	0	2		
COAL, with varying layers of stone ...	3	4		
Rib	0	1		
COAL	0	4		
		—	6	9
Bands —				
Blaes	3	0		
Sandstone	0	6		
Fire-clay	3	0		
COAL	0	4		
			6	10
First Working —				
Bands	2	0		
Fallen	0	1		
COAL, with varying layers of stone .	2	2½		
Rib	0	0½		
COAL	0	5		
Rib	0	1		
COAL	1	7		
			6	5
Floor - Sandstone	—		—	

Mr. Harry Rhodes said that the Students were indebted to Mr. Burt for a very interesting paper. With regard to stoop-and-room working, the writer seemed to find that they made larger coal in the bords than in the ends. This was the reverse of his (Mr. Rhodes') experience at collieries in Yorkshire. In some experiments made recently, bord-places produced 52 per cent. of large coal, and end-places 80 per cent. If there was any heading-out or cross-cutting, the percentage of large coal was reduced to 65.

The cost of horse-keep seemed to be high, as in Yorkshire it was about 8s. 2d. per week for feeding and grooming.

Mr. T. E. Parrington remarked that if the top stone were brushed a "second" time, it was rather costly. The writer stated that all thick seams of "minerals" could be worked by the longwall system. This was rather vague, and he did not suppose it would be possible to work by longwall an ironstone-seam 9 feet thick, such as they had in Cleveland.

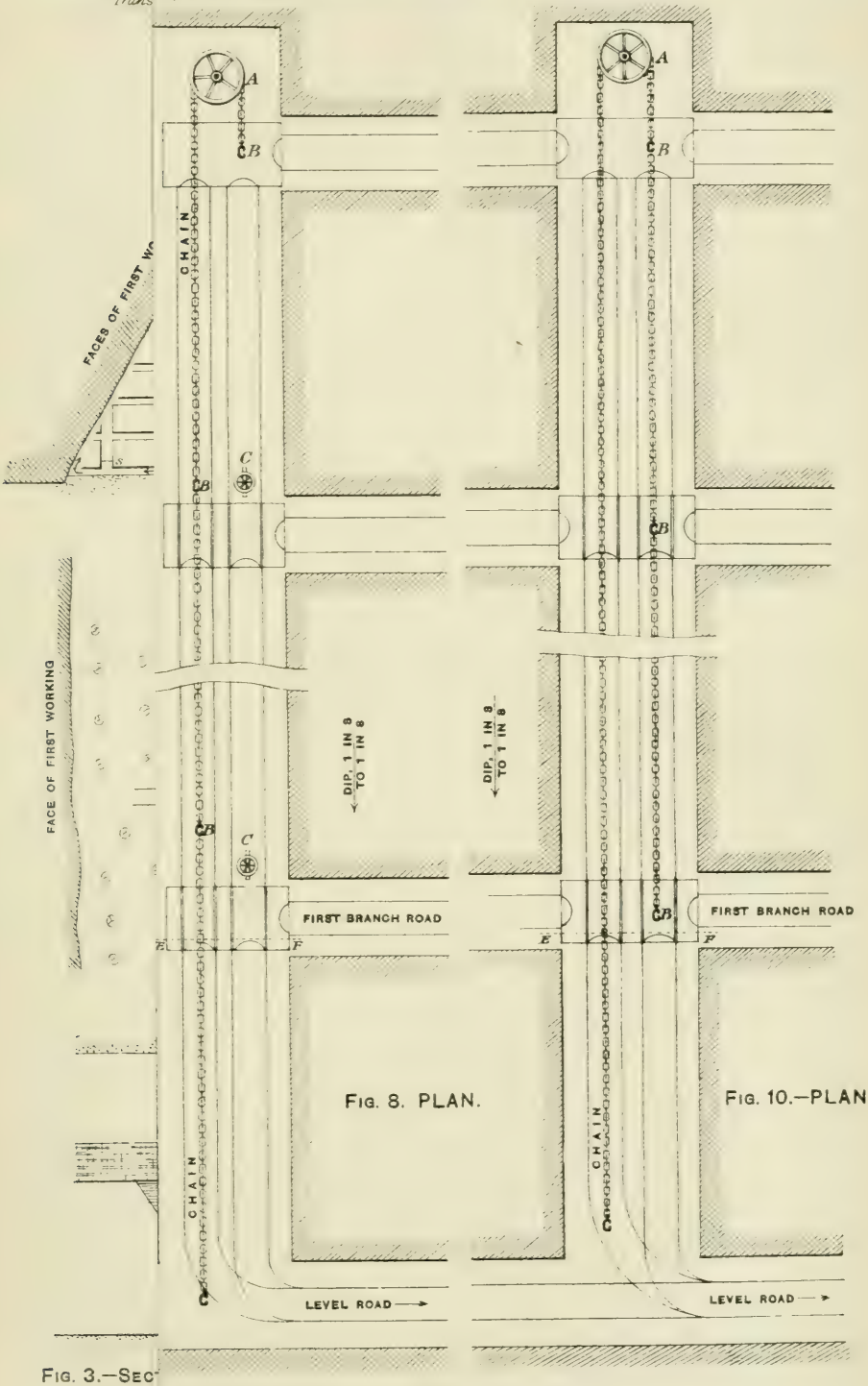


FIG. 8. PLAN.

FIG. 10.—PLAN.

FIG. 3.—SEC...

FIG. 12.—SECTION OF PLATFORM THROUGH E F ON FIGS. 8 AND 10.

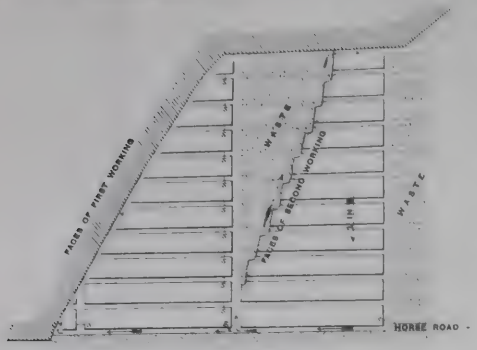


FIG. 1.—PLAN.

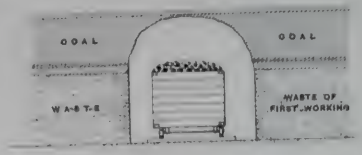


FIG. 4.—SECTION THROUGH LINE A B ON PLAN, FIG. 2.

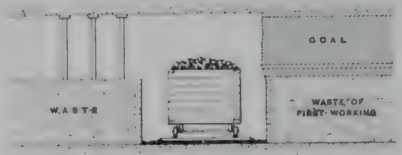


FIG 7.—SECTION THROUGH LINE A B ON PLAN, FIG. 5.

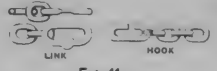


FIG. 11.

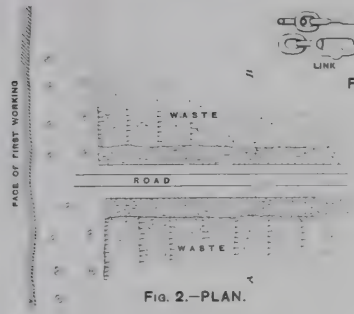


FIG. 2.—PLAN.

FIG. 9.

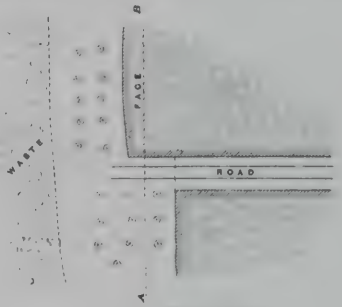


FIG. 5.—PLAN.

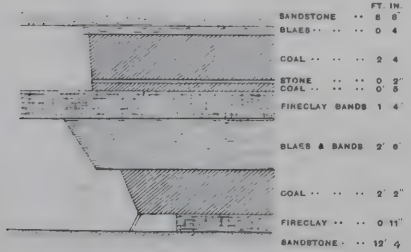


FIG. 3.—SECTION OF FACE OF FIRST WORKING, JERSEY COAL-SEAM.

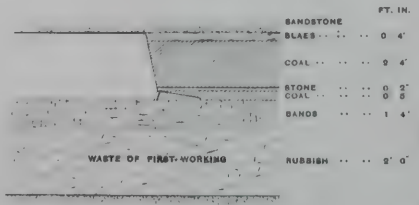


FIG. 6.—SECTION OF FACE OF SECOND WORKING, JERSEY COAL-SEAM.

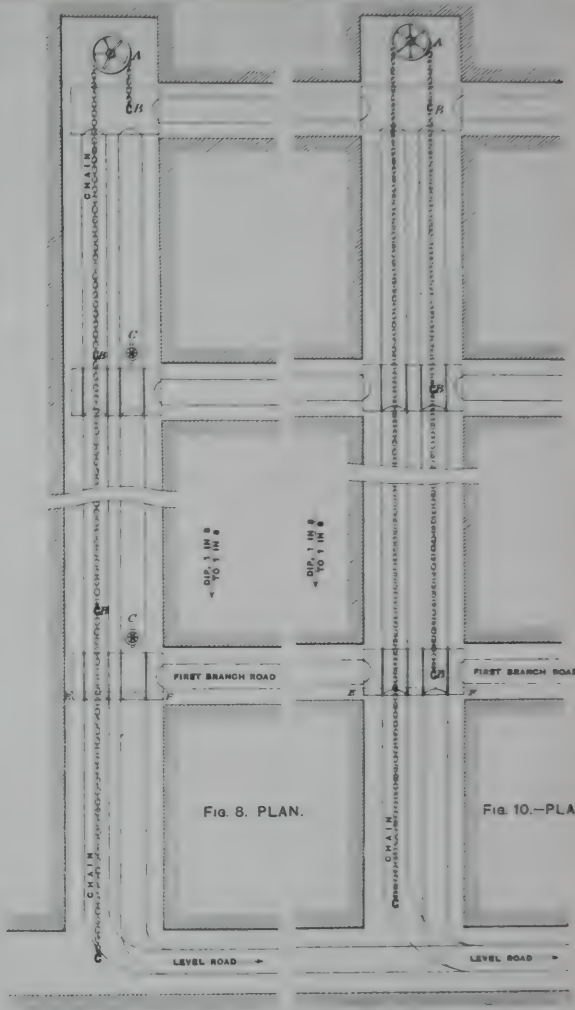


FIG. 8. PLAN.

FIG. 10.—PLAN.

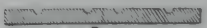


FIG. 12.—SECTION OF PLATFORM THROUGH E F ON FIGS 8 AND 10.

Mr. A. Burt said that the thick seams generally contained one or two thinner seams of sandstone, as shown in the Appendices. The distance between the headings of the bords in the stoop-and-room working varied from 90 to 150 feet.

Mr. Harry Rhodes said that at Denaby and Cadeby collieries, in South Yorkshire, a 10½ feet coal-seam was worked by longwall in one operation.

Mr. T. E. Parrington referred to the statement that in ventilating a district the air was first conducted to the dip-workings and thence to the rise-workings. If there was a large quantity of choke-damp, it would probably collect in the dip-workings, and if these dip-workings were ventilated first the tendency would be to carry the choke-damp into the rise-workings.

Mr. Harry Rhodes said that the regulations for many Continental coal-mines required that the ventilation should be ascentional, viz. :—that the air should pass uphill all the way to the highest point of the workings, and thence into the upcast shaft.

Mr. A. Burt said that the ventilating-current was split into two or more divisions as required, and the choke-damp was removed by a special current.

The Chairman (Mr. H. W. Middleton) asked how far (in the stoop-and-room working) were the whole workings kept from the broken?

Mr. A. Burt said that he thought the average distance was about 300 feet or so.

Mr. T. E. Parrington said it appeared from the paper that the stoop-and-room system was adopted where special precautions were necessary to prevent damage to buildings, etc., on the surface. He supposed that the stoop-and-room was practically the same as the bord-and-pillar system: he knew cases where the bord-and-pillar system had been the general method, except under buildings where longwall had been substituted. The idea being that, by removing the coal as fast as possible, a more even subsidence took place.

Mr. A. Burt remarked that the proprietors and landlords generally put clauses into the leases as to whether coal was to be worked on the longwall or stoop-and-room systems.

The Chairman moved a vote of thanks to Mr. Burt for his paper, in which he had gone very thoroughly into his subject. He (the

Chairman) had also the pleasure of presenting to the writer of the paper the prize of books, which had been awarded to him by the Institution.

Mr. Algernon Noble moved, and Mr. Henry D. Cowan seconded, a vote of thanks to Mr. H. W. Middleton for his services in the chair, which was agreed to.

The meeting was then closed.

The Ashington, Saint Hilda, Wallsend, and Whitburn collieries were opened to the inspection of visitors during the course of the meeting on August 18th, 19th, and 20th, 1897.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

DECEMBER 11TH, 1897.

MR. GEO. MAY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 27th and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. ROBERT BARNARD, Colliery Manager, Gangootia Colliery, Deshergur P.O., Barakur, Bengal, India.

Mr. HUBERT PERCY BARRY, Superintendent of the Waihi Gold-mining Company, Limited, Waihi, New Zealand.

Mr. JAMES BARNET BAWDEN, Mining Engineer, Shaw Street, Coolgardie, Western Australia.

Mr. THOMAS PHILIP EDWARD BUTT, Mining and Mechanical Engineer, 1, Thornhill Villas, Mannamead, Plymouth.

Mr. G. SCHMITZ-DUMONT, Acting State Mining Engineer, Pretoria, Transvaal.

Mr. F. AUG. HEINZE, Mine Smelter and Railroad Owner and Operator, Trail, British Columbia.

Mr. FREDERICK JEFFERSON, Colliery Manager, Boldon Colliery, R.S.O.

Mr. BEDFORD MCNEILL, Mining Engineer, 25A, Old Broad Street, London, E.

Mr. ARTHUR HOPE MANNING, Engineer and Mine Manager, P.O. Box 88, Heidelberg, Transvaal.

Mr. THOMAS PEARSON MOODY, Civil and Mining Engineer, Hithurangi, *via* Auckland, New Zealand.

Mr. William Waters Van Ness, Mining and Consulting Engineer, Bulawayo, Matabeleland, South Africa.

Mr. Joseph Burton Settle, Mining Engineer, Darley View, Farnworth, near Bolton, Lancashire.

Mr. Lawrence W. Tatum, Mining Engineer and Metallurgist, San Luis de la Paz, Guanajuato, Mexico.

Mr. William Denham Verschoyle, Mine Manager, Alpha Gold-mining Company, Westland, New Zealand.

Mr. Theo. F. Van Wagenen, Consulting Mining Engineer, P.O. Box 589, Telluride, Colorado, U.S.A.

Mr. William Glyde Wilkins, Civil and Mining Engineer, Westinghouse Building, Pittsburg, Pennsylvania, U.S.A.

Associate Members—

Mr. Walter Harold Brock, Umaria Government Colliery, Central Provinces, India.

Mr. Clifford J. Cory, c/o Messrs. Cory Brothers & Co., Limited, Cardiff.

Mr. William Pollard Harris, Imperial Corporation of West Australia, Tourama District, Western Australia.

Mr. Arthur Haselden, Linares, Provincia de Jaen, Spain.

Mr. Eugene Kinnaird Haselden, La Carolina, Provincia de Jaen, Spain.

Mr. Joseph Andrew Jeffrey, c/o Jeffrey Manufacturing Company, Columbus, Ohio, U.S.A.

Mr. John Alder Lumsden, Umaria Government Colliery, Central Provinces, India.

Mr. Percy William Mavor, Linares, Provincia de Jaen, Spain.

Mr. Frederick Horace Minard, 409, Equitable Building, Denver, Colorado, U.S.A.

Mr. John B. Robson, 12, Cardigan Terrace, Newcastle-upon-Tyne.

Mr. John Oliver Scott, The Glebe, Riding Mill-upon-Tyne.

Mr. H. G. Stokes, Silver Spur Silver-mine, Texas, *via* Stanthorpe, Queensland, Australia.

Mr. Harold Fairbrother Strange, c/o Johannesburg Consolidated Investment Company, Limited, P.O. Box 590, Johannesburg, Transvaal.

Mr. W. H. Wesley, The Anchor Tin Mine, Limited, Lottah, Tasmania.

Mr. W. Wybergh, Consolidated Gold-fields of South Africa, Limited, P.O. Box 67, Johannesburg, Transvaal.

Associate—

Mr. Edmund Cockburn, Back-overman, South Skelton Mines, Boosbeck, *via* Skelton-in-Cleveland, Yorkshire.

Student—

Mr. Arthur G. B. Wilbraham, Mining Student, Anglo-American Club, Freiberg, Saxony, Germany.

DISCUSSION UPON MR. W. L. AUSTIN'S PAPER ON "PYRITIC SMELTING."*

Mr. W. L. Austin wrote that Mr. Reynold's inquiry respecting the losses by volatilization in pyritic smelting touched on a very interesting point. In smelting ores by ordinary methods, there are always metallic losses not accounted for in the slags. These losses are usually ascribed to volatilization; but in reality they are of two classes: fine ore blown out of the furnace mechanically, and losses by volatilization proper. In pyritic smelting, without the use of carbonaceous fuel in the furnace, the volume of escaping gases is small, and consists mainly of nitrogen and sulphurous acid; but on account of the strong blast used, the current of escaping gases has a considerable dust-carrying capacity. This dust can, however, be readily caught in suitable dust-chambers. As far as purely theoretical subjects can be investigated in the rush of commercial operations, the volatilization of the precious metals appears to be very slight, if any at all. The question then arises, if in pyritic smelting operations there is no appreciable volatilization of the precious metals in the absence of carbonaceous gases, to what extent are such metals assisted in volatilizing by the (for want of a better term) chemical carrying power of such gases? This matter is mainly of scientific interest, for the question of losses in the fumes has been definitely settled at more than one metallurgical works, by catching all the solid matter leaving the furnace, and allowing only the colourless gases to escape.

With regard to Dr. Carpenter's work, the smelting of siliceous gold ores with only a magnesian limestone flux, it can hardly be termed pyritic smelting at all, if under that title we are to understand the use of pyritic material as a source of heat in the blast-furnace.

Mr. Louis' comments on the dearth of specific, practical information on the subject of pyritic smelting, are perfectly justifiable. But it seems to be the settled policy of managers of successful technical establishments to keep their experience to themselves. This is a lamentable fact, as far as the scientific world is concerned; but it is, with few notable exceptions, a fact. It is hardly reasonable to designate such industries "pretty subjects of theoretical speculation that have not yet emerged from the purely experimental stage," because managers do not publish the experience which they have acquired in developing certain industries.

* *Trans. Fed. Inst.*, vol. xiv., page 111.

It is, as Mr. Louis remarks, a curious fact that nothing has yet appeared in print regarding the details of the work now being carried out at a number of pyritic smelting-works, some of them quite large, and very successful commercially.

With regard to the employment of the internal-feed cylinder by the author, he advocated its use 10 years ago, and has never abandoned it; on the contrary, he is interested in further developing the system.

Dr. Bedson read the following account of "Experiments with the Shaw Gas-tester":—

EXPERIMENTS WITH THE SHAW GAS-TESTER.*

By Prof. P. PHILLIPS BEDSON, M.A., D.Sc., F.I.C., and J. COOPER, B.Sc.,
Durham College of Science, Newcastle-upon-Tyne.

At a meeting of the members of this Institute held on June 12th, 1897,† a demonstration of the working of the Shaw gas-tester was given by one of us, and in the discussion which followed Prof. Louis and Mr. M. Walton Brown drew attention to certain sources of inaccuracy in the machine and the method of working. The points raised by these gentlemen were such that doubts arose in the mind of the reader of this paper as to whether the excessive refinement claimed for the machine was altogether justified, and whether, in giving the demonstration, the apparatus had not been too leniently dealt with. It therefore appeared desirable that a further series of experiments should be made, and the outcome of these experiments it is proposed to lay before the members to-day.

Mr. M. Walton Brown directed attention to an arithmetical error in the calculation of the percentage of gas contained in a sample of air, the justification of which is at once recognized when one's attention is drawn to it. But when one calls to mind the accuracy which is claimed for this mechanical gas-tester it is not a little strange that those who have described the machine should not have directed attention to this pitfall and the necessity for an arithmetical correction of the experimental result.

In illustration of the nature of this source of error, an example may be cited. Suppose the ringing-line with a sample of coal-gas be found to be 9, *i.e.*, a mixture of 9 per cent. of coal-gas, and 91 per cent. of air is required to produce an explosion sufficiently powerful to propel the piston against the gong. If when for air there is substituted a mixture of air and gas, and now the coal-gas rings at 3·8 per cent., then, according to the instructions, the percentage of combustible gas in this mixture is to be found by subtracting 3·8 from 9, *i.e.*, 5·2 ; whereas, as a matter of fact,

* *Trans. Fed. Inst.*, vol. viii., page 161 ; and vol. xiv., page 350.
† *Ibid.*, vol. xiv., page 350.

this amount of combustible gas is contained in (100 — 3·8 =) 96·2 volumes of the mixture of air and gas. Hence the percentage is 5·2 × 100 ÷ 96·2 = 5·4—no inconsiderable error with a machine which is supposed to give the amount of combustible gas to 0·1 per cent. The error on this score alone may form a considerable percentage of the combustible gas, and vary within wide limits.

The second point raised in the discussion was that to which Prof. Louis gave utterance, viz., the justification of instituting a comparison between a pit-gas and a standard gas unless the standard gas was of the same composition as the pit-gas. The reply made by one of the authors at the meeting in June was not altogether correct, and experiments have shown the justice of Prof. Louis' contention, and further brought out the looseness with which the question of how the machine may be employed in the estimation of fire-damp in mine air has been treated by the various authors who have described the method of working.

Our experiments have been mainly directed to this point: several combustible gases have been tried against one another. The net result of these experiments has been to show that the same mixture will yield different amounts of combustible gas when tested in the Shaw gas-tester, according to the value of the "ringing-line" of the gas against which it is tested. So that the machine gives a relative, not an absolute result, and affords no information as to the nature of the combustible gas.

One or two examples will suffice to make this clear:—

(1) A sample of air from a mine was found by analysis in the Hempel apparatus to contain 20·45 per cent. of marsh gas, and with the appliance in the Shaw gas-tester a 20 per cent. mixture of this was made with air. In the Shaw gas-tester, a sample of coal-gas was found to ring at 9, when mixed with ordinary air, and against the 20 per cent. mixture coal-gas rings at 3·8. This, when corrected, corresponds to 5·4 per cent. of combustible gas.

(2) A sample of hydrogen was found to give a "ringing-line" of 11·3, when mixed with air; with the 20 per cent. mixture it was found to ring at 5·4, and this, when corrected, corresponds to a percentage of 6·2 of combustible gas in the mixture. The difference between 6·2 and 5·4 may not appear very large, yet neither of these represent the amount of marsh gas in the mixture, which, taking the analytical results, should be 4·09 per cent.

This statement shows at once that the results must be purely relative unless the standard gas is of the same composition as the combustible

gas in the mixture under examination. It will also be evident that by a simple calculation it will be possible to translate the amounts found by this machine into amounts of the combustible gas in the mixture, provided the relation between the "ringing-line" of this combustible gas and that of the standard gas be known; and in this manner fairly accurate results are to be obtained.

Thus, taking these results, the 6·2 per cent. against hydrogen may be translated into its coal-gas equivalent as follows :—$9 \times 6{\cdot}2 \div 11{\cdot}3 = 4{\cdot}9$ (by experiment 5·4). The result here must be considered only approximate, when one bears in mind the extreme delicacy of the apparatus and method.

In the several descriptions given of the Shaw gas-tester, it is generally stated that the "ringing-line" for pure marsh gas is 6 per cent. Now, taking this value, the above results may, by a similar calculation, be translated into amounts of marsh gas thus :—$6 \times 5{\cdot}4 \div 9 = 3{\cdot}6$ per cent., and $6 \times 6{\cdot}2 \div 11{\cdot}3 = 3{\cdot}29$ per cent. The percentage, based on analysis being 4·09.

(3) To give one other example :—A sample of marsh gas was prepared from sodium acetate and soda-lime, and this gas proved on analysis to contain 90·08 per cent. of marsh gas. The "ringing-line" for this gas was found to be 7, a 3 per cent. mixture was made of this gas and air, which, when tested against the marsh gas, gave a "ringing-line" of 4·2, the difference $(7{\cdot}0 - 4{\cdot}2 =)$ 2·8, when corrected arithmetically gives a percentage of 2·92, which translated into marsh gas, on the above assumption, gives 2·65. The same mixture tested against coal-gas gave a "ringing-line" of 4·8, the coal-gas having a "ringing-line" of 8·3, the difference 3·5 when corrected yelding 3·67 per cent. If this be now converted into marsh gas by multiplying by $6 \div 8{\cdot}3$, the percentage of marsh gas is 2·44. The percentage, based on analysis, was 2·7. The difference here is not so great, but it must not be forgotten that this agreement has been arrived at by corrections of two kinds, an arithmetical one of the amount indicated by the machine, and the other by the system of translation from coal-gas or other ignitible gas, in terms of a marsh-gas with a ringing-line of 6.

Taking some twelve distinct estimations of marsh-gas in mixtures containing amounts varying from 0·38 to 4·2 per cent. of this gas, the results obtained by the Shaw gas-tester gave percentages which, when corrected, differ from the percentages based on analysis by amounts varying from 0·01 to 0·5. Whilst these results may at first sight appear very satisfactory, it must be remembered that the arithmetical correction

varies from 3 to 12 per cent. of the amounts of combustible gas indicated by the machine.

The influence of this arithmetical correction becomes more important the higher the "ringing-line" of the standard gas. Thus a sample of carbon monoxide, which analysis proved to contain 88·3 per cent. of carbon monoxide, was found to ring at 20. A 1 per cent. mixture of this gas was made, tested against carbon monoxide, and the ringing-line was found to be 19, a difference of 1. But this 1 part is contained in 81 of the mixture, hence the true percentage is $1 \times 100 \div 81 = 1{\cdot}22$.

The 1 per cent. mixture tested against coal-gas with a ringing line of 8·7 gave a "ringing-line" of 8·3, a difference of 0·4, the corrected value being 0·43 per cent. This result, when translated into a gas of a "ringing-line" of 20, becomes ($20 \times 0{\cdot}43 \div 8{\cdot}3 =$) 1·04.

To show the influence of using a standard gas of low ringing-line, we we will cite some experiments made with acetylene. The acetylene was made from calcium carbide, and contained 81·2 per cent. of gas absorbed by bromine. This gas was found to ring at 3·4. A 2 per cent. mixture of this gas was made, which when tried against the acetylene, gave a ringing-line of 1·6: the difference ($3{\cdot}4 - 1{\cdot}6$) represents 1·8 per cent., here the arithmetical correction is negligible. Tried against coal-gas, the mixture gave a ringing line of 3·9, coal-gas itself ringing at 8·3: the difference therefore is 4·4, which is the amount contained in 96·1 of the mixture, or a percentage of 4·5, the actual amount of acetylene being 1·62. But this 4·5 may be corrected and expressed in terms of acetylene with a ringing-line of 3·4: it then becomes ($3{\cdot}4 \times 4{\cdot}5 \div 83 =$) 1·8 per cent.

It would, therefore, appear that, if the Shaw gas-tester is to have a more extended use, it will be necessary that it should be calibrated for the commoner combustible gases: if coal-gas be employed as a standard, the estimations made by its use, may be translated into equivalents of marsh gas, and the detection of small amounts of this gas in mine air thus made feasible. But although such an air examination is readily made, still there are rapid methods for the chemical analysis of gases, which will yield results superior to those obtained by this mechanical tester, inasmuch as they also give information as to the nature of the gases themselves.

Since the above paper was read to the members, the table printed in Appendix A has been sent to one of the writers; it shows that the necessity for correcting the indications of the mechanical gas-tester, as proved by the authors, has been appreciated by the inventor.

APPENDIX A.—Table Showing the Exact Percentage of Fire-damp in Samples Tested by the Shaw Gas-tester with Standards Ranging from 6 to 12 per Cent., and Based on the Established Fact that 6 per Cent. is the Ringing-line for Pure Fire-damp (CH_4).

Small Cylinder Retreated from Standard Line.	Standards.												
	6 %	6·5 %	7 %	7·5 %	8 %	8·5 %	9 %	9·5 %	10 %	10·5 %	11 %	11·5 %	12 %
0·5	0·52	0·49	0·45	0·42	0·40	0·38	0·36	0·34	0·33	0·31	0·30	0·29	0·28
1·0	1·05	0·95	0·90	0·84	0·82	0·76	0·72	0·68	0·65	0·63	0·60	0·58	0·56
1·5	1·57	1·45	1·35	1·27	1·20	1·14	1·08	1·03	0·97	0 93	0·90	0·86	0·83
2·0	2·08	1·93	1·80	1·68	1·59	1·51	1·44	1·36	1·30	1·24	1·19	1·14	1·11
2·5	2·59	2·40	2·23	2·09	1·98	1·87	1·78	1·70	1·62	1·54	1·49	1·43	1·38
3·0	3·09	2·86	2·67	2·50	2·36	2·23	2·12	2·02	1·93	1·85	1·77	1·70	1·65
3·5	3·59	3·32	3·10	2·91	2·74	2·58	2·46	2·36	2·24	2·14	2·06	1·98	1·91
4·0	4·08	3·75	3·53	3·31	3·12	2·83	2·80	2·67	2·55	2 44	2·34	2·25	2·17
4·5	4·56	4·23	3·95	3·70	3·49	3·30	3·14	2·99	2·85	2·73	2·62	2·52	2·43
5·0	5·05	4·68	4·37	4 09	3·86	3·64	3·46	3·30	3·15	3·02	2·89	2·79	2·68
5·5	5·52	5·10	4·78	4·49	4·23	4·00	3·79	3 61	3·45	3·30	3·17	3·05	2·94
6·0	6·00	5·55	5·19	4·86	4·59	4·34	4·12	3·92	3·75	3·58	3 44	3·30	3·19
6·5	?	6·00	5·59	5·24	4·94	4·68	4·44	4·22	4·03	3·81	3·71	3·57	3·44
7·0	?	?	6·00	5·62	5·30	5·01	4·76	4·53	4·32	4·14	3·97	3·82	3·68
7·5	?	?	?	6·00	5·64	5·34	5·10	4·83	4·61	4·41	4·23	4·07	3·92
8·0	?	?	?	?	6·00	5·66	5·38	5·13	4·89	4·68	4·49	4·32	4·16
8·5	?	?	?	?	?	6·00	5·69	5 42	5·17	4 95	4·75	4·57	4·40
9·0	?	?	?	?	?	?	6·00	5 70	5·45	5·22	5·00	4·81	4·63
9·5	?	?	?	?	?	?	?	6·00	5·72	5·48	5·25	5·05	4 87
10·0	?	?	?	?	?	?	?	?	6·00	5·73	5·50	5·30	5·10
10·5	?	?	?	?	?	?	?	?	?	6·00	5·75	5·53	5·33
11·0	?	?	?	?	?	?	?	?	?	?	6·00	5·76	5·55
11·5	?	?	?	?	?	?	?	?	?	?	?	6·00	5·77
12·0	?	?	?	?	?	?	?	?	?	?	?	?	6·00

Mr. A. L. Steavenson said that the members were very much indebted to Messrs. Bedson and Cooper for their extremely interesting and useful paper, which would add greatly to the value of the *Transactions*. He would like to ask, not only with respect to this, but to every machine, where should they use them? In the face, if they got a blower, there was no doubt about the fact of gas being there, and in a gallery they found it readily with a safety-lamp and knew what it was. It seemed to him that the only place where a testing-machine might be usefully employed was in the return-airways. Some 25 years ago, he used the Ansell indicator, but he had to give it up, because it was so uncertain in its action. He found that he could test with sufficient accuracy with the Liveing indicator. Again, supposing they wanted to try the edge of the goaf and took a sample of air, by the time the test was made the barometer had, perhaps, fallen or risen, and the conditions of the ventilation were entirely changed. With respect to the machine itself, he would

ask the inventor not to be discouraged by criticisms, but to continue to try and improve the apparatus, and he might be able to make a machine which was more reliable. He had pleasure in proposing a vote of thanks to Dr. Bedson and Mr. Cooper for their paper.

Mr. J. B. Simpson, in seconding the motion, said that the members were indebted to those gentlemen for their kindness in making the experiments with the Shaw gas-tester.

The vote of thanks was cordially adopted.

Mr. T. E. Forster asked whether differences in the composition of ordinary coal-gas were sufficient to make any difference in the results obtained by the machine. The gas made at colliery gasworks was not always of the best, and was not always purified as it might be.

Prof. H. Louis said that the paper had proved his apprehensions as to the working of the machine to be well founded. The members were much indebted to Dr. Bedson for his investigations, which showed that the machine could certainly be used for any gas, provided the gas was analysed first by the usual chemical method, otherwise the machine was useless to determine its composition, because, as he need hardly remind members, pit-gas was never pure marsh gas. Another source of error to which Dr. Bedson did not allude was that, since the machine was supposed to be used by bringing a sample of gas out of the mine in an elastic bag, the amount of gas in that bag had the greatest possible effect on the results obtained. It was quite certain that if the bag was under a certain pressure at one time and under another pressure at another time, the stroke of the piston of the machine would take in more gas on the one occasion than on the other. When, therefore, there were three distinct sources of error—variation of pressure, variation of chemical composition, and error of mathematical calculation—he thought that the machine could not be considered suitable for its purpose; its only advantage was that, with a little practice, one could get any results one pleased with it.

Dr. Bedson exhibited the working of the Shaw gas-tester, and admitted the objection raised by Prof. Louis in regard to the pressure on the rubber bag. There was also the question to be taken into account of the amount of hydrocarbons absorbed by the rubber itself, the different distensions of the bag and the different pressures on the bag, and the different mixtures of gas with which they were testing. It might be his prejudice, but naturally he preferred the chemical

method, so long as they had to bring gas to bank. He thought that chemical analysis was to be preferred to this mechanical method of testing. As regards testing in the pit, they had lamps, and also the excellent Liveing indicator, which Mr. Steavenson had mentioned.

Prof. LOUIS read the following "Notes on the Iron Industry of the Urals."

NOTES ON THE IRON INDUSTRY OF THE URALS.

By Prof. HENRY LOUIS, M.A., A.R.S.M., Etc.

The following notes do not in any way pretend to present a complete account of iron-making in the Ural mountains; they consist merely of such information as the writer was able to collect during a rapid journey through the iron-producing districts of those mountains on the occasion of the recent International Geological Congress, at which he had the honour of representing this Institute. Although they thus necessarily form a mere sketch, yet he ventures to hope that they may prove of some use, firstly, because he is credibly informed that the mines and works which were visited are typical of the general run of practice in the Urals; and secondly, because the districts studied are those most immediately adjacent to the great railway line that is ultimately to connect St. Petersburg with Vladivostok, and are, therefore, the most favourably situated from the point of view of transport, which has always been, and of course still is, the great difficulty that confronts all mining and manufacturing enterprises in the Urals.

Fuel.—The Ural mountains are well wooded, the principal timber trees being pine and beech. The forestry laws of Russia are now fairly strict, and though the owners of mines and works may cut the timber which they need upon the lands granted to them, they must replant the space so cleared, in order to maintain the existing area of forest land. Forest land is never granted gratuitously; when works are to be established, a definite area of forest land, presumed to be sufficient for the needs of the works, is applied for, and, when granted, it is surveyed and the area to be cleared annually is determined and marked out, the value of the timber thus cut being paid to the State according to an official scale of prices, which scale will not be varied during the period for which the concession is given; this period can never exceed forty-eight years. A good many of the iron-works in the Urals are owned and worked by the State, and in their case the amount of wood to be cut annually is similarly fixed by the forestry officers.

All, or practically all, the blast-furnaces in the Urals work with charcoal as fuel. The charcoal is generally of fair quality, owing to the good character of the timber employed in its production, but it is at times far from being as thoroughly carbonized as it ought to be. It is burnt either in piles, which are generally rectangular and of medium size, or in kilns; these latter are mostly of what is called the Schwartz pattern, and consist of brick chambers rectangular in plan with a semi-circular arch, closely resembling a large rectangular coke-oven. Their capacity is about 1,700 cubic feet of wood, and the yield of charcoal is on the average 78 per cent. by volume. A kiln takes about $6\frac{1}{2}$ days to burn, and $5\frac{1}{2}$ days to cool, and treats about 24 charges in the year. There seems to be little if any difference in the quality of the charcoal produced by either method, though the yield is rather higher in the kilns.

Wood is largely used as fuel in direct-fired reverberatory furnaces. In some of the more modern works it is also used to generate gas in producers of various types, this wood-gas giving most satisfactory results.

Although the Carboniferous formation is known on both sides of the Urals, workable coal-seams have hitherto only been found on the western side, and even these extend over a relatively small area. They are worked to a certain extent, but the coal produced is of decidedly inferior quality, high in ash and sulphur, and making very poor coke when it cokes at all. Coke is, therefore, barely used in smelting operations. Coal is used to some extent in works in the north-western portion of the Urals, both in reverberatory furnaces and in gas-producers. A considerable proportion of the coal so consumed is produced by the small irregular coal-field traversed by the branch railway-line from Chusovaia to Luniefsk. The total production of coal in all the Urals was only 275,000 tons in 1894, and but little of this was used in the iron industry.

In recent times, naphtha-refuse has been used to some extent both for firing boilers and heating furnaces. Careful tests are said to have shown that the heating power of naphtha refuse is from 1·6 to 2 times that of good coal; 1 cwt. of refuse is said to be equal to 44 cubic feet of wood in heating puddling-furnaces by direct firing. It is used chiefly in the south-western portion of the iron-making district, where it can be most readily imported; in that area, the cost of Astrakhan naphtha-residue is about 23d. per cwt.

Peat exists in considerable quantity in various parts of the Urals, but, though it is used locally for firing boilers, and other purposes, the writer is not aware that it is used in any way in iron-production in the Urals.

Ores.—These are very abundant, and some, at any rate, are of good quality. The most important are, perhaps, the deposits of magnetite, that are worked in various places, chiefly at Mounts Visokaia and Blagodat.

Mount Visokaia consists of a low hill of considerable extent, united to the main railway line by a short branch line starting from Nishni-Tagil station. In this hill are immense deposits of magnetic iron ore, which supply mineral to no less than six important works; the chief workings belong to the Demidoff family and to the State. The geology of this district is far from being understood, and the nature and origin of the mineral deposits are equally obscure. The ore generally occurs in immediate contact with, and surrounded by eruptive rocks, mainly felsites and felsitic porphyry, together with an epidote rock which appears to form dyke-like masses traversing the ore. All the stratified rocks of the district are highly altered and consist of crystalline limestones, tufas, schists, etc.; rocks carrying beautiful specimens of grossularia are in places associated with the deposits. The whole district shows numerous slips, faults and shear-zones. The ore consists of massive magnetite with martite in places, while some portions of it carry small quantities of copper, and are separated by hand-picking. The ore seems to occur either in irregular beds or veins, or in flattened lenticular masses with a general easterly dip, this being also the direction of dip of the accompanying stratified rocks.

Russian geologists have explained the origin of these deposits as having been due to magmatic segregation from the eruptive rock-masses, which may possibly be correct. It is, however, by no means certain that the eruptive rocks are everywhere older than the ores, and it may yet be found that the ores were originally deposited in some other form (? as spathic ore by metasomatic replacement of limestone) and were subsequently converted into magnetite and martite by the action of the eruptive rocks. Again, even if the ores owe their origin to the eruptive rocks, there is no proof that they were necessarily produced by segregation.

The method of mining is extremely primitive: the ores have everywhere been followed down from the surface in big open-cuts, forming huge basin-shaped excavations; these are cut back in inclined terraces, ore and country rock being both removed, to enable the ore to be carted along these terraces and then in zig-zags up the sides of the excavation, and then again down the hillside to the loading stations on the railway line. Great economy in mining and handling would most probably result

from the use of low-level tunnels to which the ore might be dropped by gravity, to be run out in mine trams, but this self-evident method of working does not seem to have recommended itself to anyone, although the present system necessitates the mining of at least three times as much barren rock as of ore in order to keep the terraces open for carting. It is evident that Mount Visokaia contains immense reserves of iron ore, although with the exception of a few short exploring drifts no attempt has been made to determine the continuance of the deposits.

The ore is said to be extremely pure, to average about 65 per cent. of metallic iron, and to require very little or no fluxes in the blast-furnace. It is always calcined before use. The annual production of ore is given as about 130,000 tons. The following are average analyses of the ore, raw and calcined:—

	Raw.	Calcined.
SiO_2	2·60	2·49
Al_2O_3	2·86	3·06
FeO	16·71	7·92
Fe_2O_3	74·09	83·87
Mn_3O_4	2·84	1·52
CaO	0·40	0·71
MgO	trace	1·03
Cu	0·025	0·056
S	—	—
P	—	0·02

Mount Blagodat is situated some two miles from the Kushva station in the district of Goroblagodat, and is owned by the State. It consists of a hill about 500 feet high, containing immense masses of magnetic iron ore, and bears a considerable resemblance to the last-named deposit in a good many respects.

The geological associations are somewhat similar, there being immense masses of eruptive rocks, chiefly felsite and felsitic porphyry, together with altered stratified rocks, such as crystalline limestones. Numerous minerals such as grossularia, red garnet, epidote, etc., are met with. The ore is less pure than it is at Visokaia, and seems only to yield some 55 per cent. of iron. This is apparently due to the intermixture with the magnetite of finely disseminated chlorite and garnet. The unaltered ore is bluish or greyish-black in depth, but is superficially altered to a reddish-brown shade, probably by the decomposition of some of the associated minerals. This weathered ore is considered the better of the two kinds. Like the ore from the last-named mine, and indeed from most sources, this magnetite is calcined before use in large rectangular piles, such as are used for the other ores, and which will be subsequently referred to in more detail. The

object of calcining these magnetites is, no doubt, to produce structural rather than chemical changes. When calcined in piles in the usual way, 100 cubic feet of wood will calcine 21 to 26 tons of magnetite.

The method of mining (Fig. 6) is not dissimilar to that at Mount Visokaia. On account, however, of the height and steepness of Mount Blagodat, the mines are better laid out, and are worked in the shape of a number of quarries, the floor-level of which is above that of the surrounding country, so that the ore is carted down, not up. The same arrangement of sloping terraces, forming zig-zag cart roads is, however, employed here also. An attempt at scientific mining may be seen in the form of a rock-drill. There are four drills of the Dubois and Francois type, mounted on a tunnelling carriage, working with compressed air at 30 lbs. pressure. The drills are, however, very old-fashioned and defective in construction, and are, moreover, like most of the machinery the writer saw in this part of Russia, disgracefully kept. The air-compressor is over $\frac{1}{4}$ mile away from the drills, and the air main is small, so that the efficiency of the plant must be uncommonly low. Here, as elsewhere, the miners' hand tools are rough, primitive in design, and inferior in quality. The usual practice is to drill a face, by means of the machine, with a number of holes, 6 to 8 feet in depth, batches of which are then charged with dynamite and fired by means of ordinary fuzes. The method of mining appears to be both irregular and expensive. A certain amount of prospecting has been done here, a borehole having been put down to a depth of 700 feet, at which point it is still in ore.

Mount Blagodat produces about 60,000 tons of ore annually, and employs about 600 men.

There are numerous smaller magnetite deposits in the Urals that produce a good deal of ore. There are also very many deposits of chrome iron ore of good quality, containing 35 to 40 per cent. of chromic oxide. In the Urals, as elsewhere, this ore occurs in close connexion with serpentinous rocks, which are largely developed in various parts of this mountain chain.

Red hæmatites occur in various places. A wellknown locality is that of Puchia, where red and brown pisolitic and oolitic iron ores, apparently stratified, are found in limestones of Devonian age. This ore may carry up to 50 per cent. of metal, and is said to contain 1 per cent. of phosphorus. Other deposits of red hæmatite are said to occur in rocks of Carboniferous age in this district, and to contain up to 64 per cent. of iron.

Specular ore is also mined in the Urals.

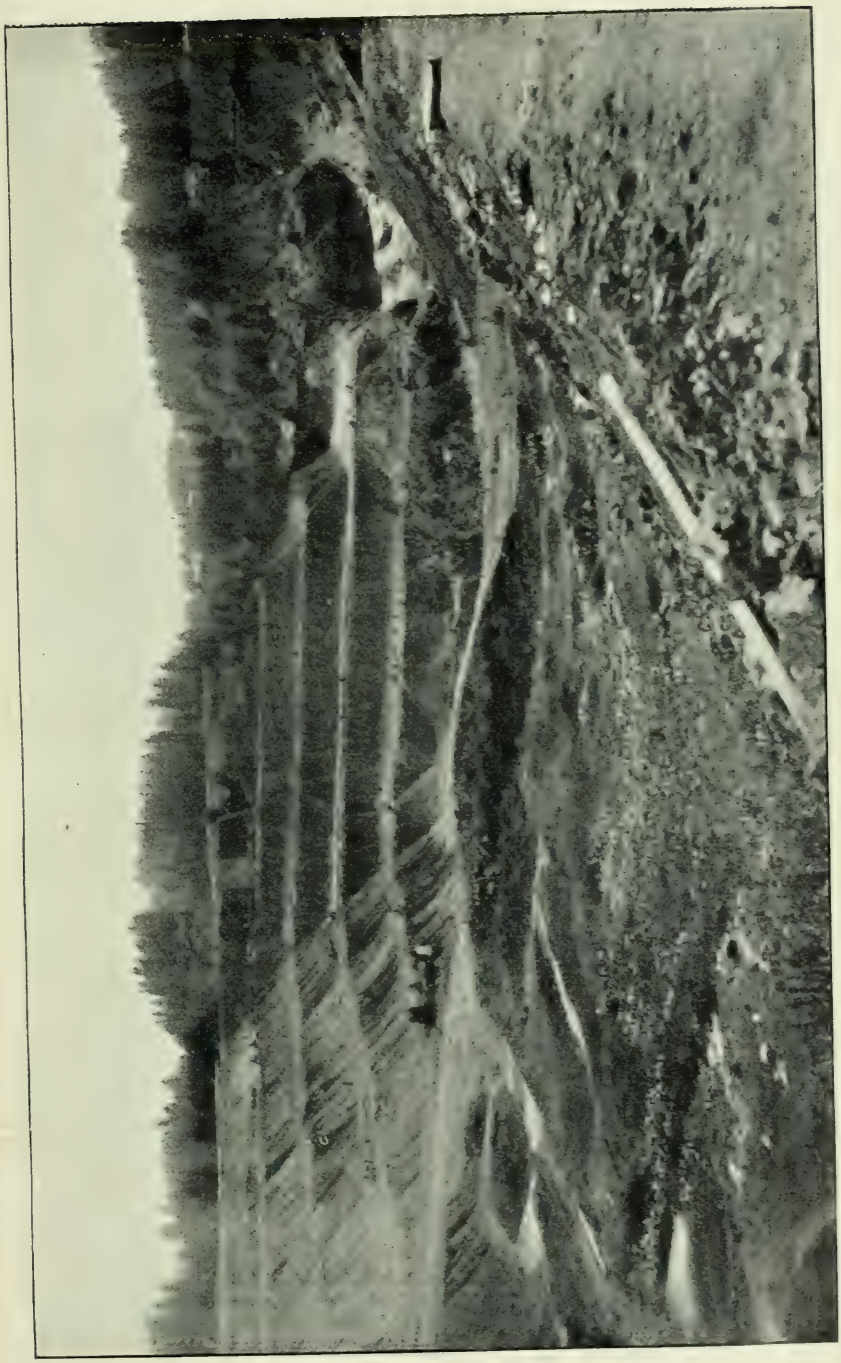


FIG. 6.—No. 9 IRON-ORE MINE ON MOUNT BLAGODAT.

Brown hæmatite and spathic iron ores are produced on a large scale in the important mining district of Simsk, at the mines of Bakal, and various others, which are divided amongst three owners, Messrs. Balachef, Prince Bieloselski-Bielozerski, and the State. These mines, which, together, produce about 100,000 tons annually, and employ about 1,750 men, are situated some 25 miles to the south of the railway line between the stations of Viasovaia and Suleia, the road being execrably bad in summer, though it is said to be well adapted to winter traffic by means of sleds.

All these mines present similar geological features; the country consists of schists of Lower Devonian age, interstratified with dolomites and overlain by quartzites, which constitute the serrated ridges of the hills; these rocks are underlain by other beds of quartzite, the ore-bearing formation being bounded by the upper and lower quartzite-beds. All these formations are traversed by dykes of diabase, at times interbedded amongst the stratified rocks. The ore, when opened up in depth (250 feet below its outcrop), is seen to be a massive siderite or spathic ore, but nearer the surface (down to a depth of over 150 feet) it has been converted into brown hæmatite. It is distinctly interstratified with the shales, and shows structure parallel to the stratification, whilst irregular masses of dolomite project into it, the passage between the two being apparently gradual. There can be little doubt that the calcareous rocks have been converted metasomatically into spathic ore by the action of ferriferous solutions, the origin of which may possibly be connected genetically with the outbursts of diabase. The spathic ore has been converted superficially into brown hæmatite by atmospheric action in the ordinary wellknown manner, the limit of this action being locally about 200 feet below the outcrop of the ore. These deposits thus present well marked genetic affinities with those of Bilbao.

The method of mining is practically identical with that described at Mount Visokaia, the principal mine (Fig. 7) being 120 feet deep, and being also cut into terraces in the same way as the latter. This mine produces about 500 tons of ore per day, but can only work in the summer months, say for 100 to 120 days in the year. The climate here is severe, as the mines are situated 5,000 feet above sea-level. The brown ore can be got with the pick only, but the spathic ore, of which a relatively small quantity is produced, requires blasting. The miners are paid according to the amount of ore got, the price being said to vary from 10s. 6d. to 17s. per ton, the lower figure being paid for brown ore, and the higher for spathic ore; the owners furnish tools and dynamite, the consumption of

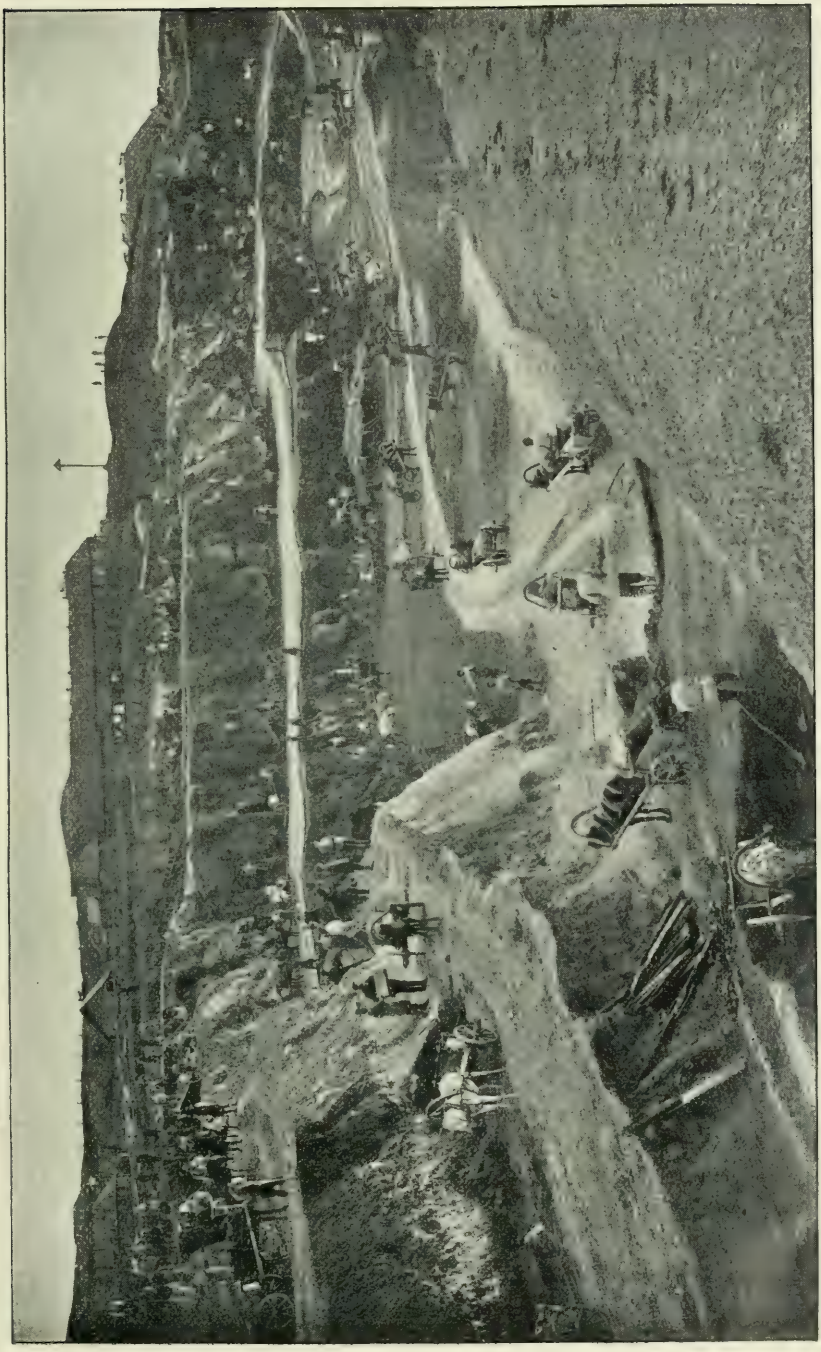


FIG. 7.—No. 2 IRON-ORE MINE AT BAKAL, BELONGING TO MESSRS. BALACHEF.

the latter being only about 13 cwts. per annum. The above price is paid for both getting the ore and for carting it out of the mines, which is done in small carts carrying about 6 cwts. If the above prices are correct (and they certainly seem far too high), it only serves to show how badly the mines are laid out and organized, and how dear cheap labour can become, seeing that the average wages of miners in the Urals are only about 1s. 6d. per day.

All the ore is calcined in big rectangular piles, containing about 10,000 tons of ore. When brown ore is being calcined, a bed of cord-wood about 4 feet 6 inches deep is laid down, and upon this the ore is piled to a depth of about 19 feet; for spathic ore, the proportion of ore to fuel is about 3 to 1. These piles will burn for about one month.

All the ore is transported to the railway during the winter time by means of sleds drawn by one horse. Each sled will carry 10 to 15 cwts. of ore, and makes five trips per week; some 400 horses are thus employed.

The most recent complete statistics published by the Russian Department of Mines, refer to the year 1894; in that year there were in the Urals 868 iron mines of all sorts in operation, and these produced 880,000 tons of ore, with the labour of nearly 21,000 men, or but little over 40 tons per head per annum. Compared with the total production of iron ore in Russia, the output of the Urals has commenced to decline in recent years, as shown by the following figures :—

	Iron Ore Produced in	
Year.	The Urals. Tons.	All Russia. Tons.
1886	673,000 ...	1,072 000
1890	907,000 ...	1,768,000
1894	880,000 ...	2,447,000
1896 (estimated, unofficial)	572,000 ...	1,600,000

Blast-furnaces.—There are a very large number of blast-furnace plants scattered throughout this region, each works having as a general rule two furnaces, though the numbers vary from one to four. The furnaces are mostly small, the average output being about 20 to 25 tons of pig in 24 hours. They are usually somewhat old-fashioned in type, though improvements have recently been introduced in a good many places; a certain number of Rashette furnaces (oval in plan) are still in operation, although they are gradually being replaced by the ordinary circular type. On account of the severity of the climate, furnaces and pig bed are enclosed in a substantial brick building, which usually has a cupola-

like roof covering the furnace-tops (Fig. 8). Both hot and cold blast are employed, the blast-pressure being, as a rule, between 1 and 2 lbs. to the square inch. All these works are situated in valleys, so that large water reservoirs can be obtained by constructing a low dam across the valleys in question: some of these reservoirs constitute veritable lakes several miles in circumference. The object seems to have been not only to obtain the water required in the works, but also a cheap and ready source of power, most of the works having been built before the utilization of the blast-furnace gases for steam-raising had been introduced. The sites thus selected for the works are convenient for obtaining their supplies of fuel, but often present serious disadvantages as regards both carrying in the ore, and disposing of their production of pig-iron and castings. A more detailed description of a few of these works will perhaps give a sufficient idea of the stage of devolopment of the pig-iron industry.

Simsk Works, owned by Messrs. Balachef Brothers, and smelting the calcined ores from the Bakal district, are situated about 5 miles from the station of that name. They are now being connected to it by means of a narrow-gauge tramway. There are two blast-furnaces, the section of which is shown in Fig. 1 (Plate XIX.). They have brick stacks, iron hooped, and carried on brick arches; as is the case with most of the furnaces in the Urals, the crucible and all the stack up to the boshes, are not built of brick, but are made by ramming a suitable mixture of sand and clay round a wooden pattern into an outer retaining wall. This part of the furnace lasts for about 20 months. The furnaces are open-topped, the gases being drawn off by a side pipe.

The charge consists of :—

Fuel, 4 boxes of charcoal (equal to 60 cubic feet).
Ore, about 0·6 ton (calcined spathic ore and brown hæmatite, containing 60 per cent. of iron).
Flux, dolomitic sand, equal to 10 per cent. of the ore.

Each furnace puts through 65 to 75 charges in 24 hours. The charcoal is dropped in direct. The ore and the dolomite used for flux are mixed, scattered uniformly round the circumference of the furnace, and then shovelled into it. The charcoal and ore-sheds are some little distance from the furnace-bottom; the charges are adjusted there, run in boxes suspended from a roller, running on an overhead rail by means of rope haulage, to a small rope-hoist, driven by a 24 horse-power turbine, which lifts them to the level of the furnace-top. They are run in the same way, but by hand, from the hoist to the furnace-mouth. There are about 20 men engaged per shift on the furnace-top, the same gang working both furnaces.

The blast is produced by means of three horizontal blowing cylinders, lying side by side, and driven by a 125 horse-power vertical turbine. Each cylinder is 5 feet in diameter, 5 feet stroke, and makes 17 to 22 strokes per minute, 19 being about the average for the two furnaces. The quantity of blast is about 5,000 cubic feet of air per minute, at a pressure of $3\frac{1}{4}$ to $3\frac{3}{4}$ inches of mercury. The blast is heated in cast-iron pipe-stoves, containing 11 rows of oval pipes, with 3 arches in each row; the temperature is between 300° and 400° Cent. There are 3 tuyeres, water-cooled, about 4 inches in diameter; the nozzles, about $2\frac{1}{2}$ inches in diameter, enter these tuyeres, but are not packed, so that much air escapes backwards and does not enter the furnace at all. The front is closed, with a short tymp; the cinder runs from the notch over an inclined cinder-bed, where it sets, and is pulled away by hand. The production of cinder is not large, and there are 2 to 3 flushes to each cast.

The pig-iron produced is chiefly grey and of fine quality, largely used for foundry purposes. Each furnace produces about 20 tons in summer and 30 tons in winter per 24 hours. There are 4 casts in 24 hours from each furnace, the iron being run into sand-moulds. There are about 10 men at work on the pig-bed per shift.

There is a foundry attached to the works, in which the pig is remelted in a wood-fired air-furnace. Very fine castings are produced; their value is stated to be £17 per ton at the works. There are also steel works, etc., attached to these works, which will be referred to later on. There are said to be over 600 men employed at these works, of whom 80 are engaged about the blast-furnaces.

The average year's work of these two furnaces is as follows:—

Ore smelted	16,600 tons.
Fluxes smelted	1,350 ,,
Charcoal	2,250,000 cubic feet (about 11,000 tons).
Pig-iron produced ...	10,000 tons (or 59·5 per cent. of the ore).

The Sutkinsk Works are the property of the State; they are situated some 10 miles from Suleia station, and also treat the ores of the Bakal district. There are two blast-furnaces, an older one of the Rashette type 16 feet by 10 feet in the boshes, with four tuyeres in each of the longer sides, the cinder notch in one of the shorter ends, and the tap hole in the other. The second furnace is a newer one, and is circular, 13 feet in diameter at the boshes, with five tuyeres. Both are of the same height, namely 47 feet. The older furnace produces about 48 tons of pig-iron per day, whilst the newer one produces about 29, but the latter works far

more economically as regards fuel; it treats 1·4 tons of ore to the ton of charcoal, whilst the Rashette furnace only treats 1·25 tons with the same amount. The comparison thus afforded between these two types of furnace is the main point of interest about these works. According to the governmental returns, the average year's work at these furnaces is :—

Ore smelted	32,500 tons.
Slags	110 ,,
Fluxes	3,000 ,,
Charcoal	3,400,000 cubic feet.
Pig-iron made	19,500 tons (60 per cent.).

There are no less than 200 men employed about these furnaces, and it may be interesting to state that the area of forest land apportioned to the use of these works is 334,300 acres. As very little except blast-furnace work is done at these works, there being only five puddling-furnaces here, an idea can be formed of the amount of forest land required for the production of charcoal iron, though there are few works that have so large a proportion as the above.

It is estimated that an acre of forest land yields about 3,430 cubic feet of wood fit for charcoal burning, and that this wood produces about 2,300 cubic feet of charcoal; the wood cut for charcoal seems to be at least of 60 years growth, so that the minimum area of forest land that will support a blast-furnace can readily be calculated. The official estimate is, that an acre of Ural forest land will give at most 2,600 cubic feet of charcoal, and often only half that amount.

The Baranchinsk Works (Fig. 8) are government works, using principally ore from Mount Blagodat. There are two furnaces here, No. 1 being a modern circular furnace, the section of which is shown in Fig. 2 (Plate XIX.) whilst No. 2 is an old-fashioned Rashette furnace, with boshes about 12 feet by 18 feet, and with two tuyeres in each of the longer sides, and one in the back (not in use at the time of the writer's visit); the cinder notch and tap hole are both in front. No. 1 furnace is externally octagonal in plan, the upper part of the stack being contained in a retaining wall of red brick hooped and braced with iron, whilst the portion below the boshes is iron-cased. There are four tuyeres in the alternate panels of the octagon; these are small spray tuyeres. Both furnaces are of the same height, and both are worked with open tuyeres, *i.e.*, with the nozzles not clayed in. The furnaces are open topped, and no hot blast is used. The charge consists of six boxes of charcoal, each weighing about 6 cwts., which are dumped into

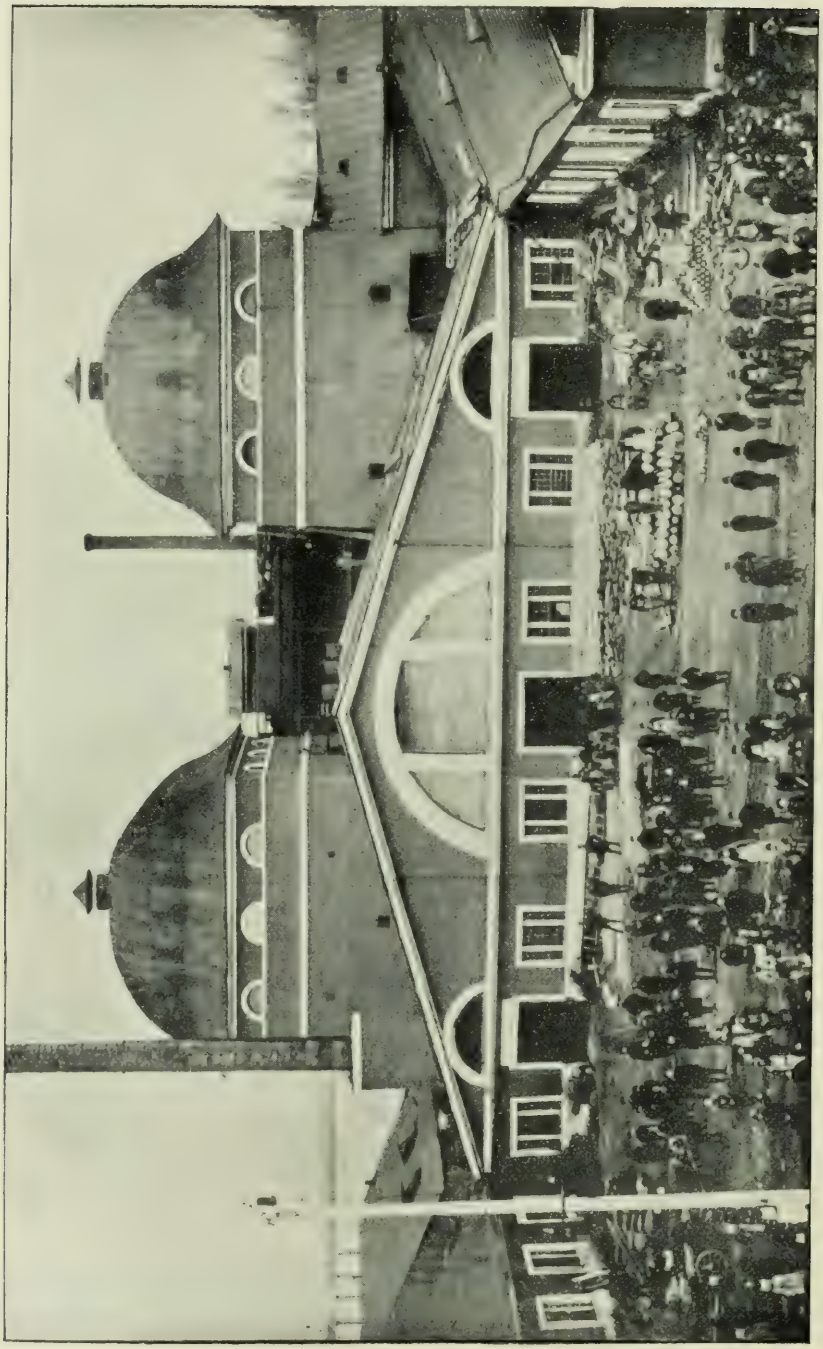


FIG. 8.—BLAST-FURNACES AT BARANCHINSK.

the furnace followed by a number (apparently irregular) of flat sheet-iron trays containing ore (calcined magnetite and some calcined brown hæmatite), foul slag with shots of iron, and limestone (about 5 per cent. of the weight of the ore). It is said that the Rashette furnace will take about 70 boxes of charcoal with its proportion of ore and flux, whilst the circular No. 1 furnace takes about 45 boxes. The new furnace is said, however, to do rather the better work of the two. The blast is generated by means of a pair of horizontal cylinders, 5 feet 8 inches in diameter and 5 feet 9 inches stroke, driven at 20 strokes per minute by a 90 horse-power turbine, and forcing 8,500 cubic feet of air per minute at a pressure of $2\frac{3}{4}$ inches of mercury. Another similar pair of cylinders, steam driven, is kept in reserve in case of need.

The water is usually distributed in all the Ural works by means of large wooden tubes built up of staves and iron-hooped. The water is said never to freeze, provided it is kept running.

In addition to the blast-furnaces, there are at the Baranchinsk works a large shell-foundry, and fairly well equipped machine shops for turning and finishing the shells. The iron is remelted in the foundry by means of two wood-fired air-furnaces.

The average annual results of these works are :—

Ore smelted	15,000 tons.
Flux	600 ,,
Charcoal	2,750,000 cubic feet.
Pig-iron produced	8,800 tons (58·9 per cent.).

There are about 100 men engaged about the blast-furnaces, together with between 500 and 600 outside labourers.

At *Chusovaia* there is a big ironworks owned by a French limited liability company, called the Kama Company. There is here one blast-furnace which has only been built some 4 or 5 years, and is, therefore, a good example of the most modern type of blast-furnaces in the Urals. The furnace is about 60 feet high; the stack of brick, iron-hooped, rests on brick pillars, the crucible and lower part of the furnace being cased in boiler-iron. The tuyeres, of which there are three, are ordinary water-tuyeres, and the blast-nozzles are packed tightly into them, the pressure of the blast being from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches of mercury. There are a pair of iron pipe hot-blast stoves, heating the blast up to about 400° Cent. The furnace has a closed top; this consists of an iron lid with a central pipe for taking off the waste gases. This pipe is connected with the gas downtake by a hinged joint in such a way that the cover, which is counterpoised, may be turned up, and leave the top free when the furnace is to be charged.

The charcoal, most of which is burnt at the works, seems to be rather inferior in quality; it is swung over the open furnace-top, by means of a crane, in an iron box with a drop bottom, which opens on knocking off a catch. The ore and flux are charged in a more complicated manner. A travelling-carriage running on rails, which is of about the same diameter as the furnace-top, is placed just clear of the top. On this carriage rests a circular iron box rather over a foot deep, the bottom of which consists of an iron plate with radial slots, having an angular width of some 10 degrees; there is a second similar plate below this one, which can be turned through a little over 10 degrees, so that the slots in the lower plate can be made either to coincide with those in the upper one, and thus open the box, or else to coincide with the spaces between the slots in the upper plate, when the bottom of the box is closed. This is its usual position, and when thus set, a box of about one-third its diameter with a conical bottom, containing the weighed ore and fluxes, is hoisted into the middle of the above shallow box. By loosening a catch and hoisting, the ring-shaped walls of this second box are lifted clear of the bottom, when the mixed ore and flux slide off the cone into the annular space in the larger box. Thus prepared, the carriage is pushed into position over the furnace top, when, by turning the lower plate of the large box, the ore and flux are allowed to drop evenly distributed into the furnace. Seeing that the charcoal is in very big lumps, whilst the rest of the charge is broken very small, it may be questioned whether it is worth while making use of so elaborate and cumbersome a distributor. The ore is mainly Puchia ore, with about 15 per cent. of magnetite.

The make of pig-iron is said to be about 20 tons per day of white iron, which is cast in chills; these are arranged in rows running downwards from the furnace, and each row is filled in turn by means of a revolving spout. The pig iron produced is said to contain 1 per cent. of phosphorus.

The average annual work of this furnace is as follows :—

Ore smelted	7,300 tons.
Fluxes	1,100 ,,
Charcoal	1,235,000 cubic feet.
Pig-iron made	3,100 tons (42·4 per cent.).

The production of pig-iron is one of the less important operations at these works, which also make wrought iron and steel; the same company owns two other works, at one of which there are four blast-furnaces producing something like 20,000 tons of pig-iron annually.

Although the writer happened to have visited none of their works, this portion of the subject would be incomplete without some reference to the

work done in this district by the Demidoffs, who are the leading iron-masters here. Their principal establishments are at Nishni-Tagil and Nishni-Saldinsk. They own altogether 2,345,000 acres of land of which 1,980,000 are forests. They have 11 blast-furnaces in operation, 1 of which is reserved for making ferro-manganese and ferro-silicon, and occasionally ferro-chrome, whilst the other 10 make ordinary pig-iron. Their records go back to the year 1758, when they produced 6,650 tons of pig-iron and about half that quantity of wrought iron. In 1895, the production of their blast-furnaces was :—

	Tons.	
Pig-iron ...	61,900	(P, 0·06 per cent, S, 0·02 per cent, Cu, 0·06 per cent.)
Ferro-silicon ...	130	(20 per cent. Si)
Ferro-manganese	230	(80 per cent. Mn.)
Total	62,260	

The ore smelted in this year amounted to 95,400 tons, the bulk of it being magnetite from the Demidoff mines on Mount Visokaia, containing 65 per cent. of iron. The other ores are brown hæmatite from Schilofsk, with about 57 per cent. of iron when calcined, and manganiferous ore from Sapalsk with over 50 per cent. of manganese. These ores are now largely calcined in kilns instead of in piles, much fuel being thereby economized. The consumption of charcoal in the blast-furnaces to produce the above amount of pig-iron was 15,640,000 cubic feet; it is said that the charcoal smelts its own weight of pig-iron in the furnace. Various forms of hot-blast stoves are used, some being iron pipe-stoves, heating the blast to 250° Cent. and some Cowper stoves heating it to 500° Cent.

The works of the Demidoffs are thus, evidently, the most progressive in the Urals, and the iron industry of this region largely owes its present development, no less than its original expansion, to the enterprise of this princely family.

Reference must also be made to the works at Kussa and Kishtim, in both of which places, though especially in the latter, small iron castings are made which are remarkable no less for their artistic modelling than for their beautiful finish. The better qualities will fully sustain comparison with the famous Berlin castings, and have, indeed, but few equals in the world.

The Urals are gradually losing their relative importance as the leading district for the production of pig-iron, as shown by the following table :—

Year.	Urals. Tons.		All Russia. Tons.
1886	300,000	...	520,000
1890	400,000	...	912,000
1894 ...	534,000	...	1,312,000
1896 ...	571,600	...	1,600,000
1897 (first six months)	332,600	...	914,000

Wrought Iron.—This is still largely made in the Urals, being used extensively in the form of bars by country smiths, and also being worked up into the well-known Russian sheet iron; the manufacture of these sheets is to-day practically still identical with the process as described by Dr. John Percy in 1871, and will hence not be further described here. Some iron rails of light sections are rolled in places, some boiler plate is also made, as well as merchant bars of various sections. Iron is still made to some extent in charcoal fineries, but these are now dying out and being replaced by puddling-furnaces, which were first introduced about 1850. The former are still preferred for making sheets. The latter are of various types, single and double, and mostly wood-fired, though in the south-western portion of the district naphtha residues are being used with advantage, and seem to be coming into favour.

Miniarsk Works.—These works are situated about 2 miles from the station of the same name, with which they are connected by a narrow-gauge tram line. They make only puddled iron and finished iron, chiefly round, square and flat merchant bars, tees and angles, plates, sheets, etc. The pig-iron is obtained from the Simsk blast-furnaces, both works belonging to the same owners; the pig-iron is chiefly grey, with a little mottled and white. The original form of puddling-furnace was a double furnace, wood-fired, the draught being produced by a stack; these produced only 29 cwts. of puddle bar in 24 hours, and are hence being replaced by oil-fired furnaces; the last one was just being torn down at the time of the writer's visit.

The oil-fired furnaces are also double furnaces, worked by a puddler at either side; there is one helper to each furnace per shift. There is of course no fire-place, but merely the puddling chamber, and beyond it a heating chamber, in which the pig-iron is heated to redness before being charged into the puddling-furnace proper. Above this heating chamber rises a short stack containing a serpentine cast-iron pipe, making three bends, one vertically above the other. The blast is made to pass through this pipe, and is thus heated to a certain extent; it is then carried by a pipe to the opposite end (corresponding to the fireplace-end in ordinary

furnaces) of the furnace, where it enters through a narrow horizontal slot; just above this slot there are a couple of narrow nozzles connected to a pipe about 2 inches in diameter, through which naphtha residue is forced by means of a small pump. The construction of this burner is shown in Figs. 3 and 4 (Plate XIX); it is made of about $\frac{3}{8}$ inch iron plate. As the oil drops down in front of the thin flat air-blast, it is caught by it and blown into spray, which at once ignites, forming a blow-pipe flame, which is directed down upon the bed rather beyond its centre. By regulating the supply of air and oil, the flame may be made reducing or oxidizing at will, and is under complete control. The roof of the puddling-furnace forms a much flatter arch than is usual in coal-fired reverberatory-furnaces. The blast is produced by a Root blower. This furnace has air-cooled boshes and is fettled with talcose schist. The firebricks used in these furnaces, as well as in the mill-furnaces, are silica bricks, made by crushing burnt quartz, mixing with 2 per cent. of lime, moulding and burning; their cost is said to be about £3 15s. per thousand. This furnace takes a charge of $11\frac{1}{4}$ cwts. of pig iron, and makes $35\frac{1}{2}$ cwts. of puddle bar in 24 hours. The forehand puddler is paid 3s. $2\frac{1}{2}$d. per day, the second hand, who takes the back door of the furnace, 2s. $6\frac{1}{2}$d., and the helper 1s. 7d. per shift. In these furnaces 1 cwt. of naphtha residue will produce 4 to 5 cwts. of puddled iron, the latter figure being high. The iron produced is of very high quality, of very even grain, and crystalline rather than fibrous. The balls are shingled under a helve. The mill furnace is of the usual type, fired with wood-gas. The producer consists of a rectangular brick chamber with firebars at the bottom, about 5 feet square and 17 feet deep down to the bars, burning 340 cubic feet of wood in 24 hours. The wood is introduced by means of a cast-iron box, about 4 feet by 2 feet 6 inches by 2 feet deep; the cover is set in a water-seal and the bottom is hinged, so that the producer can be charged without any air being admitted. The rolls are of the usual type, three-high, driven by turbines on vertical spindles.

A very large and handsome new puddling and rolling-mill is just being finished. There are 8 double puddling-furnaces, oil-fired, the burners being identical with those already described. The blast is, however, heated by passing below the bed of the furnace, which is fitted with water-boshes. These furnaces are built in pairs, a Galloway boiler being placed between each pair and fired by their waste heat; the boiler-water is heated by passing through the water-boshes of the furnaces. There are 2 Worthington pumps respectively for circulating the water and for pumping the oil from a storage-tank to the furnaces. There is a $2\frac{1}{2}$ ton steam hammer,

and two mill trains driven by an engine of 375 indicated horse-power. The reheating furnace is fired with wood gas, and is regenerative.

These works employ about 1,000 hands all told. It is worth noting that they are laid idle two to three months every year, between July and September, to allow time for getting in the harvest. In 1894, there were 10 puddling-furnaces at work, producing 6,700 tons of puddle-bar.

Chusovaia Works.—There are here 16 puddling-furnaces, all wood-fired; they are double furnaces, the men working side by side at the doors marked 1 and 2 in the sketch-plan (Fig. 5, Plate XIX.). *A* is the fire-place, *B* the furnace body, and *C* a preheating stove for heating the pig-iron before it is charged into the furnace proper. The waste heat is used for firing boilers. Each furnace uses 340 cubic feet of wood in 24 hours, and produces up to 38 cwt. of blooms in that time. The blooms are shingled under a small steam hammer, and reheated in a large Bicheroux furnace fired with coal. The mill train consists of 1 pair of breaking-down rolls and 1 pair of mill-bar rolls, both two-high. Some of the iron is at times finished in the steel rolling-mill, consisting of a three-high train; in this mill re-heating is done in Siemens furnaces. These works turn out about 12,700 tons of puddle-bar per annum.

The statistics for 1894 show that there were in the Urals in that year 309 charcoal-fineries and 365 puddling-furnaces, which produced respectively 78,000 tons of blooms, and 290,000 tons of puddle-bar. The progress of wrought iron manufacture is shown by the following table:—

Year.	Urals. Tons.		All Russia. Tons.
1886	190,000	...	357,000
1890	225,000	...	426,0 0
1894	289,000	...	570,000
1896 (estimated, unofficial)	244,000	...	494,000

Steel.—Up to comparatively recent times considerable quantities of puddled steel, cement steel and crucible steel were produced in the Urals. The open-hearth process and the Bessemer process were both introduced in the same year, 1876, by the Demidoffs, whose services to the iron industry of this region have already been referred to, and these newer methods of steel-making have, to a great extent, replaced the older ones. There are at present in the Urals, two Bessemer plants with two converters each, at Nishni-Saldinsk and at Katav-Ivanofsk. Open-hearth furnaces are more numerous, these being in operation at 12 works, with a total of

22 furnaces. The quantities of the various kinds of steel made in the Urals in 1894 were as follows :—

	Tons.
Cement steel	1,200
Puddled ,, ...	1,900
Bessemer ,, ...	48,200
Open-hearth steel...	30,000
Crucible ,, ...	4,100

The Bessemer works present no especial peculiarities ; the converters are 4 tons converters, and make 30 blows in 24 hours, though the actual time of a blow is only 12 to 14 minutes. The steel is cast into ingots weighing 5 to 6½ cwts., and practically the whole of it is used in rail manufacture ; the demand for rails in Russia is a rapidly growing one, and this district in particular is well situated for supplying the Trans-Siberian railway now under construction.

At the Simsk works, there is one open-hearth furnace making Siemens-Martin steel. There are three gas generators identical with those at Miniarsk situated close to the furnace, wood being the fuel used. The gas and air-valves are reversed every half-hour. The brick used is a silica-brick identical with that used at Miniarsk. The furnace-bottom is composed of lumps of chrome-iron ore, resting upon a brick foundation, the actual bottom consisting of crushed chrome-iron ore mixed with 2 per cent. of lime, rammed into the furnace and fired. It makes an admirable bottom, very hard and close in texture, and extremely infusible. The furnace takes a 10 tons charge of pig and scrap and more or less ore, according to the proportion of scrap available ; the ore used is the ordinary calcined Bakal ore, such as is used in the blast-furnaces at these works. The actual time of working a charge is about 7 hours, but only two charges are got out in 24 hours. The steel produced is said to contain 0·12 per cent. of carbon and 0·03 per cent. of phosphorus. It is partly cast into ingots, which are sent to Miniarsk to be rolled, and is partly used for making steel castings, which are rather rough and imperfect.

At Chusovaia, the ingots are cast by ascension in groups of 8 ingots placed round a central vertical runner. There is nothing else about the steel-making, as practised in the Urals, that calls for any special remark.

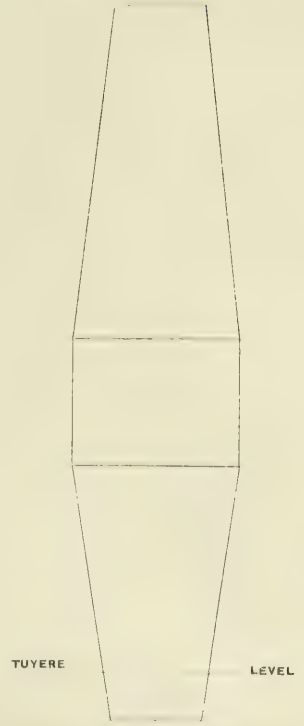
Whilst the production of steel, both in Russia as a whole and in the Urals, has been growing rapidly, the growth is confined to the cheaper grades, namely, Bessemer and open-hearth steel, the output of the other qualities showing a gradual decline. The Urals never occupied as pro-

minent a place in the Russian steel-manufacture as they do in that of pig and bar iron ; they produce, and have for some time past produced, just about 10 per cent. of the total output of the empire.

It may be noticed that in this rapid sketch of the iron industry of the Urals, the writer has dwelt more especially upon the more primitive processes, and such as are likely to be dying out. But this is merely because these are the processes that future observers will have less opportunities of studying, and not because he attaches to them any special industrial importance, or that he wishes to gloss over the real advances that have been made in this district in recent years. There is no doubt much to be done before the district, as a whole, can come abreast of the times, though some of the best works are conducted on thoroughly sound principles. The most striking point about the industry is its wholesale waste of human labour. To produce 500,000 tons of pig-iron, there are 7,500 men employed about the blast-furnaces, whilst the total iron industry of the Urals employs no less than 48,800 workmen, with 85,800 labourers ; to these we must add the 20,900 men employed in the mines, giving a grand total of 155,500 men engaged in the iron industry of this district, who only produce, say, 250,000 tons of pig and and an equal weight of malleable iron and steel. Making every allowance for the inclemency of the climate, as well as for the fact that wood-cutting and charcoal burning necessitate the employment of a very large number of men, who are, of course, included in the above figures, the quantity of labour is out of all proportion to the production of iron, and we have once again the fact demonstrated that low wages do not necessarily mean cheap labour.

As to what the future of this iron-producing region will be, it is difficult to draw any very certain conclusion. Hitherto experience in every part of the world has shown that charcoal iron cannot in the long run compete against iron made with mineral fuel, and that the proper site for ironworks is on the fuel-producing coal-fields, and not at the mines yielding the ore. In the case of the Urals, there are, however, a few considerations to be taken into account that cannot be paralleled elsewhere. In the first place, a good many of the works belong to the State, which will keep them up for the sake of the high quality of their products, the latter being required for military purposes, in which cost is a subordinate consideration. Then, again, the principle of conservation of the forests, now being applied in the Urals, has not, so far as the writer knows, been tried in

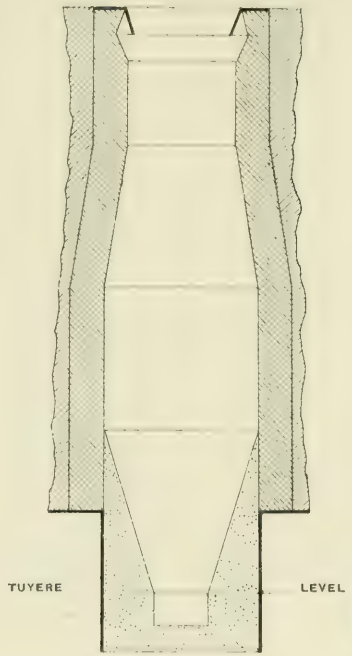
FIG. 1.



BLAST-FURNACE AT SIMSK WORKS.

Scale, 15 Feet to 1 Inch.

FIG. 2.



No. 1 BLAST-FURNACE AT BARANCHINSK WORKS.

REFERENCE.

SAND AND CLAY, RAMMED.

INNER LINING.

OUTER WALL.

BURNER FOR NAPHTHA RESIDUE MINIARSK PUDDLING-FURNACE.

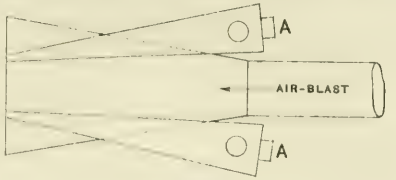


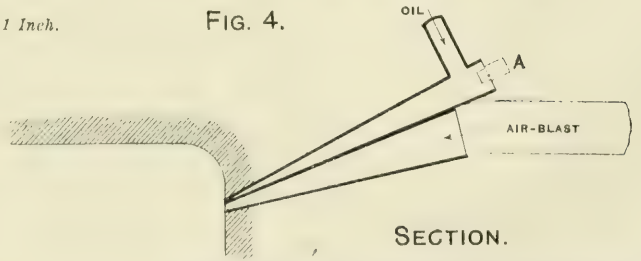
FIG. 3.

PLAN.

A A ARE PRICKER-HOLES FOR CLEARING OIL-JETS, WITH PLUGS.

Scale, 1 Foot to 1 Inch.

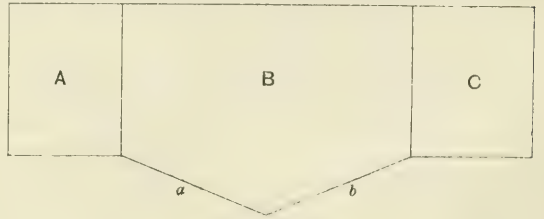
FIG. 4.



SECTION.

DIAGRAMMATIC PLAN OF DOUBLE PUDDLING-FURNACE AT CHUSOVAIA WORKS.

FIG. 5.



REFERENCE.

A—FIREPLACE. B—FURNACE-BODY. C—HEATING-STOVE.
d, b WORKING-DOORS FOR TWO PUDDLERS.

North of England Institute of Mining & Mechanical Engineers Transactions 1878

And^w Reid & Comp^y L^d Newcastle on Tyne

VOL. XIVII. PLATE IV

similar cases elsewhere, and in other countries the forests have receded so fast from the furnaces as to cause, on this account alone, the extinction of the latter.

The Urals will, for many years to come, be able to supply the extensive regions of Siberia with charcoal iron cheaper than iron made with mineral fuel can be imported; as communications improve, however, this advantage will constantly diminish. On the other hand, much of the internal traffic of Russia is carried by the Volga and its affluents; a considerable portion of the iron region of the Urals is drained by the rivers Chusovaia and Bielaia, as well as by the Kama, into which the two former flow, and all these rivers are navigable. Hence the iron produced in this section of the Urals has only to be carried down stream, whilst that of its chief competitor, the Donetz basin, has to be transported up stream. Moreover, the Urals have the advantage of relative nearness and water communication to Nishni-Novgorod, the great central mart of Russia; as long as this locality retains its commercial supremacy—which shows, however, already some signs of declining—the Urals can send iron to it more readily than any other iron-producing region. It would seem, therefore, that the iron industry is likely to survive many years yet in the Urals, although this district is fast losing, if it has not indeed already lost, the premier position which it once held amongst the iron-producers of the Russian Empire.

Mr. C. H. Stevenson said that Prof. Louis had read a very useful paper, and he had pleasure in proposing a vote of thanks to the writer.

Dr. P. P. Bedson, in seconding the vote of thanks, said that he was very much interested in some of the points raised, especially the survival of the use of charcoal in the production of iron, which had practically disappeared in this country. Another point was the use of chrome-iron ore in forming the beds of open-hearth furnaces, and this called to mind some experiments which Sir Lowthian Bell made in Cleveland with the view of de-phosphorizing the steel by means of chrome-ironstone hearths in the furnaces.

Prof. Louis acknowledged the vote of thanks.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

STUDENTS' MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 11TH, 1897.

MR. R. R. SIMPSON IN THE CHAIR.

The CHAIRMAN presented the President's prizes to the writers of the following papers :—

"Cornish Methods of Mine-timbering." By Mr. G. P. Chaplin.
"Economical Combustion of Coal for Steam-raising Purposes." By Mr. T. E. Parrington.

DISCUSSION UPON MR. T. E. PARRINGTON'S PAPER ON "ECONOMICAL COMBUSTION OF COAL FOR STEAM-RAISING PURPOSES."*

Mr. R. R. SIMPSON wrote that although agreeing in the conclusions which Mr. Parrington had drawn in his interesting paper, he might mention one or two points in which he appeared to be inaccurate. In the first place, the total products of the analysis of the coal used in the experiments was given as 87·6 per cent., leaving 12·4 per cent. unaccounted for—this seems rather too large an allowance for sulphur and ash.

Judging from the quantity of air supplied in the experiments (15 to 20 pounds per pound of coal), one is inclined to suspect that a considerable amount of incomplete combustion would take place, resulting in the formation of carbon monoxide and consequent loss of heat. The more usual allowance of air is about 18 lbs. for forced-draught, and 24 lbs. for ordinary chimney-draught.

In estimating the number of thermal units derived by the combustion of the hydrogen contained in the coal, Mr. Parrington has omitted to

* *Trans. Fed. Inst.*, vol. xiii., page 384.

make allowance for the amount of heat required to maintain the product of combustion (water) in a state of vapour—on applying this correction, the value 62,032 becomes reduced to 52,490 thermal units. The amount of heat generated by the combustion of the sulphur in the coal is also omitted; this is perhaps hardly appreciable, but it may be mentioned that 1 pound of sulphur in burning evolves 3,996 thermal units.

In calculating the saving of coal effected by the increase in the number of boilers, it seems hardly correct to fix the selling price of the coal saved at 6s. per ton. Presuming that these experiments refer to colliery plant, an allowance of 4s. per ton would perhaps be nearer the mark, as it must be remembered that the coal used for firing the boilers at most collieries is very inferior.

The cost of the extra labour entailed by the use of the additional boiler is omitted in the calculations in the paper.

A much greater waste of fuel than that dealt with by Mr. Parrington occurs at the majority of collieries, owing to the use of low steam-pressures, a common working pressure being about 60 pounds per square inch (absolute). A glance at Dr. Regnault's tables shows that the total heat, from 32° Fahr. contained in 1 pound of steam at 60 pounds pressure (absolute) is 1170·7 units; whilst for steam at 150 pounds pressure (absolute) the total heat is 1190·7 units. Thus for a more than doubled steam-pressure, the extra amount of heat required is under 2 per cent. of the whole amount. In other words, by doubling the steam-pressure the same amount of energy can be developed by using only one half of the fuel.

Mr. John Cadman read the following "Notes on Rearer Workings":—

NOTES ON REARER WORKINGS.

By JOHN CADMAN.

The following notes are intended to describe the methods employed in the working of the coal-seams lying on the western side of the North Staffordshire coal-field.

The inclination of the coal-seams in some parts of that district is very considerable, not only appearing in a vertical position but exceeding it, so that the floor of the seam becomes the roof. Numerous seams of workable coal occur, and the following is a section in the lower measures :—

Name of Coal-seam.	Average Thickness. Feet.	Approximate distance between Seams. Feet.
Single Four Feet	4½ to 5 ...	... 42
Single Two Feet	2 ,, 3½ ...	... 27
Single Five Feet	4½ ...	... 72
Ragman	3 to 3½ ...	... 21
*Rough Seven Feet	7 ...	... 12
*Hams	4 ...	... 222
Ten Feet	7 to 8½ ...	... 54
Top Two Row	2¼ ,, 3 ...	... 39
Bottom Two Row	2¼ ,, 3 ...	... 306
Seven Feet Bambury	6 ,, 7½ ...	... 111
Eight Feet Bambury	6 ,, 7½ ...	... 153
Bullhurst	7½ ,, 14	

* The Rough Seven Feet and Hams coal-seams in some places occur almost as one seam, with about 6 to 12 inches of lass parting between them.

The coal-seams have almost every variety of roof and floor, and are also very much cut up by faults, whose displacements vary from a few inches to 2,000 feet.

Seams having a higher gradient than 45 degrees are called "rearers," and it is found impracticable to work such seams by the longwall system.

Mode of Working.—A modification of the pillar-and-stall system is usually adopted. The breadth of coal, recovered at one time, generally varies from 350 to 750 feet, that is the distance from the bottom level to the old workings above. This recovery is made by sinking the pit to a depth estimated from the area required and the inclination of the seam,

and then driving a crut or cross-measures drift, intersecting the measures at right angles (Fig. 1, Plate XX.). The breadth being recovered, levels are driven out on either side to within 180 feet of the boundary, and at this point three heads are driven to the full rise of the seam, viz., a cage or brake-dip *A*, usually used as an intake-airway, a return-air-dip *C*, and a travelling-dip *E*, which contains steps or ladders.

The dips and crosscuts are usually driven about 36 feet apart. These dips are driven to within 30 feet of the old workings laying above, and a series of levels are then driven out each way for 180 feet, the top ones being driven in advance of the lower. When the top levels are driven to their distance, thurlings are driven up to the gob, and the rib of coal is then drifted back or worked out to the dip *A*.

When the first drift has advanced 30 or 35 feet, the next drift below is opened, and so on down the dip, but it is rare that more than three drifts on either side are working together (Fig. 2, Plate XX.). The two drifts on the same level are wholly worked out together so as to enable the brake-wheel to be lowered to the next level below. If the roof be bad, pillars of coal, about 15 feet wide, are left on either side of the dip, until the brake-wheel is lowered. These pillars are then taken out, the coal slipping into a screen at the side of the brake-wheel from which the coal is loaded. A breadth of 360 feet of coal is worked from a set of dips, the cage-dip being placed in the centre of the breadth.

Drifting.—There are two principal ways in vogue of drifting or of removal of the pillars of coal. In the first of these, the coal-face is kept at an angle of about 45 degrees to the level, which is (about) the line of cleavage. There are always 4 or 5 rows of props standing in a drift, and a rib of coal of about 3 feet in average thickness is left at the top of the drift to keep the gob from slipping down and filling up the drift (Figs. 2 and 3, Plate XX.).* As the drift advances, the last row or two of props are drawn, and as soon as the upper two or three props supporting the rib are knocked out the gob slips down into the open drift. A wooden mallet with a long handle is used to knock out the top props.

When the coal is fairly strong, the gob may not slip when the top props are knocked out, and a "bodger" is then used; it is 10 or 15 feet long, and consists of a wooden bar with a steel spike, about 1 foot long. The workman stands behind some timber near the drift-face, and bodges or works out the bottom of the rib until the gob forces its way through.

Frequently the seam is more easily worked in one direction, owing to

* This method of drifting was illustrated by a model.

the prevalance of cleats or slips, and as the coal has to be drifted back to the dips from two opposite directions, one of these will be the least favourable one for getting the coal. To obviate this disadvantage, drifting is generally done in the same direction as on the other side of the dips, but from a fast end, or from a thurling, for a distance of about 30 feet; when this distance is worked out, a new drift is started 30 feet nearer the dips (Fig. 2, Plate XX.). This is called a "back-way" drift, while the opposite or an ordinary drift is called a "face-way" drift.

In the thicker seams, the coal is not holed to any extent in drifting, being wedged in fiery mines, and blown down by explosives to the slips in non-fiery mines. The collier works on a scaffold (Fig. 4, Plate XX.), formed either by laying posts lengthways between props set 4 or 5 feet apart, and allowing small coal to level up, or by spiking a rail or batten across two props and placing boards from the rail to the floor of the seam.

The second method of drifting is to shoot the gob and allow it to entirely fill up the drift, a breasting from 6 to 9 feet wide is then taken up bank, as shown in Fig. 5 (Plate XX.) In this case, the workmen can stand on the gob to work, and avoid the use of scaffolding to a great extent.

When the breasting is within 3 feet of the old workings above, a shot is put in the rib, which blows through the rib and allows the gob to slip.

This method is found to be rather more expensive than the first method, and it cannot be employed with safety in a fiery mine owing to the risks in blasting the rib, or what is technically known as "shooting the gob."

As some of the coal-seams are very liable to spontaneous combustion (especially the Bullhurst), great care has to be observed in their working, because these fires frequently occur in seams producing much fire-damp and very dusty, so that in addition to the fire itself there is a risk of serious explosion.

As a preventative to spontaneous combustion, the following method of working the coal is sometimes adopted. The gob is allowed to fill with gas, and as each pillar of coal is worked out on the rise, the next level below becomes the return airway and the gob above becomes charged with gas, only allowing sufficient ventilation to pass so as to keep the edges of the gob and working-places free from gas.

Another method frequently adopted is to work the coal out in panels, leaving a solid rib of coal about 60 feet wide between each panel, con-

taining about 1,080 square feet. As each panel becomes exhausted, they are entirely built off, the gob being thus hermetically sealed. Of course, the thickness of the rib entirely depends upon the nature of the coal-seam.

The Cage-dip is the road from the higher working-levels to the lower main level or haulage-road. Cage-dips are fitted up in two ways, either with two cages, or with one cage and one counterbalance.

The double cage-dip is usually of a permanent kind, generally adopted when the coal to be worked out requires to be braked more than once, owing to the great breadth ; and until the top breadth is worked out, two cages are used.

The cage and counterbalance is arranged so that the counterbalance either runs by the side of the cage or underneath it. The gauge of the cage-wheels varies from 3 to 4 feet and that of the counterbalance from $1\frac{1}{2}$ to 2 feet. The dips are usually laid with bridge-rails placed on battens. The sleepers are fastened either by being sunk into the warrant or thill, and placed above two props one on either side, or by being spiked (spike-holes having been drilled into the floor for this purpose). The cage (Figs. 6 and 7, Plate XX.) consists of a wooden frame and two pairs of wheels. The waggon is received on rails, and the requisite catches are provided to prevent the waggon from slipping off the cage. The weight varies from 10 to 12 cwts. One cage is capable of running from 100 to 120 tons of coal down a dip, 300 feet in length, in a shift of 8 hours. The counter-balance or dummy is a low weight-carriage on wheels, and is fastened to the rope by glands, so as to allow of the length of the rope being adjusted from time to time.

The brake-wheel used in cage-dips is shown in Figs. 8 and 9, (Plate XX.). A wooden segment or felloe block *A*, clips one-third round the wheel, and is fastened to an iron brake-strap *B B*, which is connected to the brake-lever *C*. The rope, usually $\frac{1}{2}$ to $\frac{5}{8}$ inch in diameter, is wrapped $1\frac{1}{2}$ times round the wheel, which is 4 feet in diameter. The wheel is generally set on the dip, and is only placed vertically when the dummy or counter-balance runs underneath the cage.

Frequently in the double cage-dip system, a special form of brake is used, consisting of two wheels, having three rope-grooves in the upper wheel and two in the lower one (Figs. 10 and 11, Plate XX.). The rope thus makes three half-turns round the upper and two half-turns round the lower wheel. This arrangement is very effective, the friction produced by the contact of the rope and the wheel, $2\frac{1}{2}$ times its circumference

instead of 1½ times, as in the former wheel, being sufficient to hold a great weight. In order to allow the loads to run on and off the cage from intermediate levels, short rails are thrown across, called "tab rails." These rails are usually hinged to the sleepers, and can be turned back when not in use.

In conclusion, the writer might add that dips of from 65 to 90 degrees are found easiest to work, as the gob shoots down regularly and fills up most of the space, and so protects the roof round about the coal-face. Naturally, in steep workings, the gob has to be carefully watched, and the workmen have to be constantly on the alert. In some of these coal-seams the workmen have occasionally to resort to speedy flight, owing to a sudden total or partial shooting of the gob.

The CHAIRMAN said that he was particularly interested in this paper, because, during the summer, he had the pleasure of going down some of the mines that the writer had described, and he could testify to the dangers of mining in that district. A man who worked in the Staffordshire mines would be able to work in any mine in the world. He proposed a vote of thanks to Mr. Cadman for his interesting paper.

The motion was unanimously adopted.

Mr. CADMAN exhibited and explained a model illustrative of his paper.

Fig. 8.—Plan.

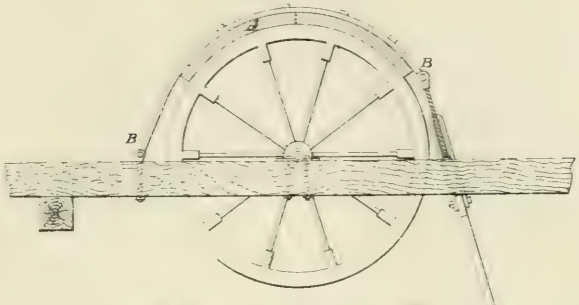
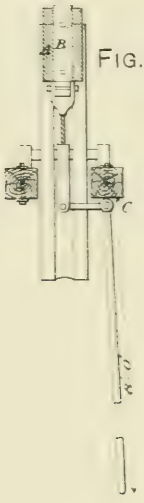
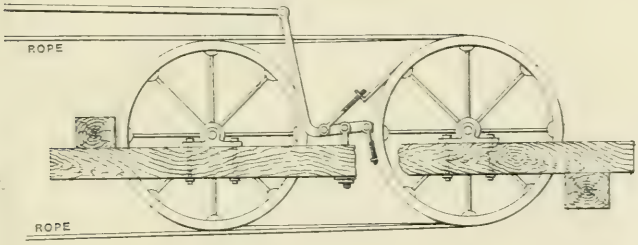


Fig. 9.—Section.



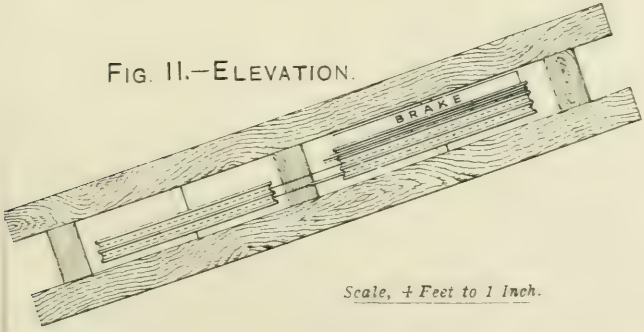
Scale, 3 Feet to 1 Inch.

Fig. 10.—Plan.



Scale.

Fig. 11.—Elevation.



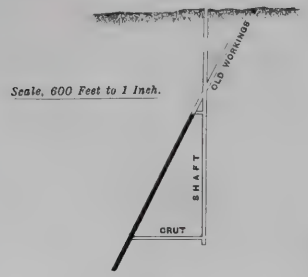
Scale, 4 Feet to 1 Inch.

North of England Institute of Mining & Mechanical Engineers' Transactions, Vol. [illegible]

To illustrate Mr. John Cadman's "Notes on Reaver Workings."

Vol. XIV. Plate XV.

FIG. 1.



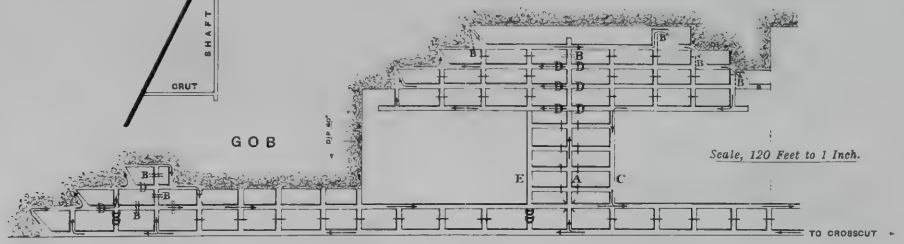
Scale, 600 Feet to 1 Inch.

REFERENCES.

STOPPINGS — DOORS

AIR-CROSSINGS — BRATTICE

DIRECTION OF AIR-CURRENT — SCALE OF AIR-CURRENT



Scale, 120 Feet to 1 Inch.

FIG. 2.—PLAN.

FIG. 8.—PLAN.

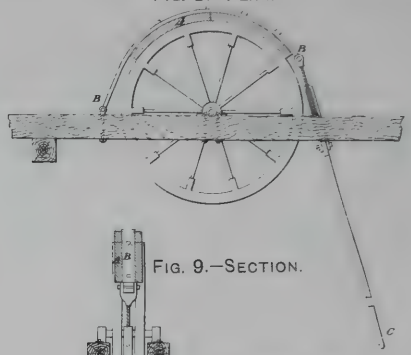
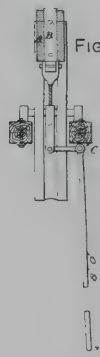


FIG. 9.—SECTION.



Scale, 3 Feet to 1 Inch.

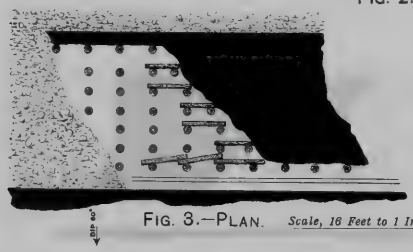
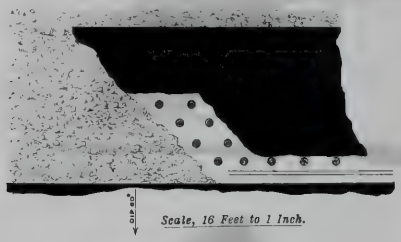


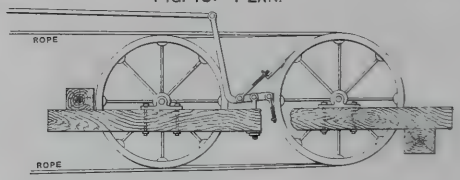
FIG. 3.—PLAN. Scale, 16 Feet to 1 Inch.

FIG. 5.—PLAN.



Scale, 16 Feet to 1 Inch.

FIG. 10.—PLAN.



Scale, 7½ Feet to 1 Inch

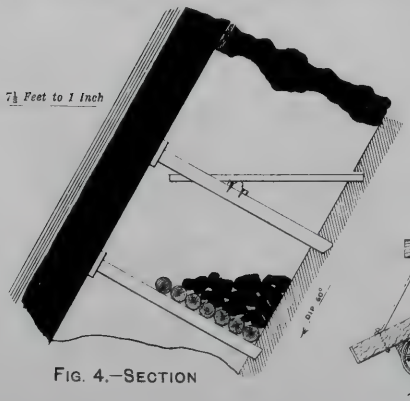


FIG. 4.—SECTION

FIG. 6.

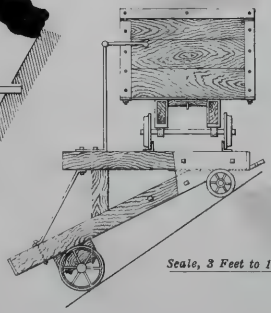
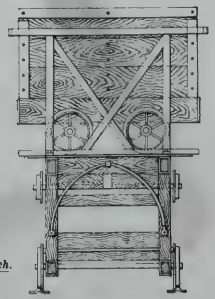
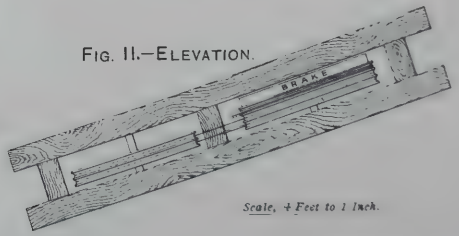


FIG. 7.



Scale, 3 Feet to 1 Inch.

FIG. 11.—ELEVATION.



Scale, ½ Feet to 1 Inch.

North of England Institute of Mining & Mechanical Engineers' Transactions Vol. XLVII.

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Vol. XLVII. Plate V.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
FEBRUARY 12TH, 1898.

MR. GEO. MAY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on January 29th and that day.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Sir CHARLES MARK PALMER, Bart., M.P., Grinkle Park, Loftus, R.S.O.

MEMBERS—

Mr. THOMAS L. BATES, Government Inspector of Collieries, Hamilton, Newcastle, New South Wales.

Mr. WILLIAM CHARLTON, Mining Engineer, Guisborough, Yorkshire.

Mr. JAMES FALSHAW COOK, Mechanical Engineer, Washington Ironworks, Washington, Co. Durham.

Mr. JOHN DIXON, Senior Government Inspector of Collieries, Merewether, Newcastle, New South Wales.

Mr. C. FERGUSON, Colliery Manager, Walbottle Colliery, Newcastle-upon-Tyne.

Mr. ARTHUR DARLING NICHOLSON, H.M. Inspector of Mines, 14, Chatsworth Square, Carlisle.

Mr. ALBERT JOHN ALFRED ORCHARD, Mining Engineer and Manager of Nailstone Colliery, near Leicester.

Mr. WILLIAM THOMAS REES, Mining Engineer, Maesyffynon, Aberdare, South Wales.

Mr. JOHN J. SANDEMAN, Mining Engineer, 17, Berners Street, London, W.

Mr. DAVID CURLE SMITH, Mechanical and Electrical Engineer, Little Sylvester Street, Coolgardie, Western Australia.

Mr. JOHN JAMES TURNBULL, General Manager, East Indian Coal Company, Limited, Jherryia P.O., District Manbhoom, Bengal, India.

Mr. JOHN VAUGHAN, Mechanical Engineer, Balaclava House, Dowlais, South Wales.

Mr. PHILIP GALBRAITH WATSON, Colliery Manager, Blaydon Burn Colliery, Blaydon-upon-Tyne.

ASSOCIATE MEMBERS—

Mr. HERBERT AINSWORTH, P.O. Box 1,553, Johannesburg, Transvaal.
Mr. CHARLES JOHN BANKS, Westwood, Washington, R.S.O., Co. Durham.
Mr. VICTOR M. BRASCHI, Bajos de Portacoeli No. 11, Ciudad de Mexico, Mexico.
Mr. HENRY HOLLIDAY, Consett Iron Company, Limited, Blackhill.
Mr. EDMUND GEORGE LAMB, Old Lodge, Salisbury.
Mr. STEPHEN E. LAMB, 6, Charles Street, Berkeley Square, London, W.
Mr. DAVID H. LAWRANCE, c/o R. S. Cunningham & Co., 91, Cannon Street, London, E.C.
Mr. P. W. D. PICKUP, Rishton Colliery, Rishton, near Blackburn.
Mr. THOMAS SAMPY, Stockton Colliery, Newcastle, New South Wales.
Mr. D. W. A. SAUNDERS, Worcester Chambers, Swansea.
Mr. SAMUEL STEWART, 16, Great George Street, Westminster, London, S.W., and Parkhurst, Park Road, Wallington, Surrey.
Mr. TREVOR F. THOMAS, Llandaff Place, Cardiff.
Mr. E. A. WEINBERG, Queensland Smelting Company, Limited, Aldershot, Maryborough, Queensland, Australia.
Mr. JOHN WELFORD, Tighes Hill, Newcastle, New South Wales.

ASSOCIATES—

Mr. JOHN CARROLL, Deputy-overman, East Hedley Hope Colliery, Tow Law, R.S.O., Co. Durham.
Mr. JAMES E. DAVIS, Assistant Manager and Surveyor, South Medomsley Colliery, Dipton, R.S.O., Co. Durham.
Mr. F. DAVISON, Middle-shift-overman, 58, Hedley Hill Terrace, Waterhouses, Co. Durham.
Mr. MATHEW DAVISON, Back-overman, Hedley Hill Colliery, Waterhouses, Co. Durham.
Mr. WILLIAM HALL, Under-manager, Elswick Collieries, Newcastle-upon-Tyne.
Mr. ALEXANDER HAMPSON, Under-manager, St. Helen's Colliery, Bishop Auckland.
Mr. GEORGE HARE, Under-manager and Surveyor, Seghill Colliery, Northumberland.
Mr. DEMSTER HORNSBY, Assistant Under-manager, Murton Colliery, *via* Sunderland.
Mr. JAMES NICHOLSON HUGHES, Under-manager, Hedley Hill Colliery, Waterhouses, Co. Durham.
Mr. ROBERT KELLETT, Overman, Littletown, near Durham.
Mr. WILLIAM LITTLE, Deputy-overman, Linton Colliery, Morpeth.
Mr. JOHN MARSHALL, Under-manager, Cheetham Lane, Swinton, near Manchester.
Mr. WILLIAM ROWLAND OWEN, Miner, 32, Duke Street, Millom, Cumberland.

STUDENTS—

Mr. W. S. BARWICK, Mining Student, 713, Burrard Street, Vancouver, British Columbia.
Mr. WILLIAM B. COXON, Mining Student, Langley Park Colliery, Durham.
Mr. GLANVILLE REAH, Mining Student, Newlands, Gosforth, Newcastle-upon-Tyne.
Mr. ARTHUR JOHN WALTON, Mining Student, Seghill Colliery, Northumberland.

AWARDS FOR PAPERS.

The SECRETARY read the following list of papers communicated during the year 1896-97, for which prizes of books had been awarded by the Council to the authors :—

"The Gold-fields of the Hauraki Peninsula, New Zealand." By the Rev. Joseph Campbell.

"Cornish Methods of Mine Timbering." By Mr. G. P. Chaplin.

"The Mineral Resources of the Colony of Queensland." By Mr. William Fryar.

"Notes on the Coal-seams of the Transvaal, and Description of a Modern Pit-head Plant." By Mr. W. T. Hallimond.

"Notes upon Foreign Mining Laws, and Adequate Areas for Mining Concessions." By Mr. H. D. Hoskold.

"The Education of Metallurgists." By Mr. Saville Shaw.

"Notes on the Sinking of Two Shafts at Claravale Colliery." By Mr. F. R. Simpson.

DISCUSSION ON MR. FRANK REED'S PAPER ON "HYDROTHERMAL GOLD-DEPOSITS AT PEAK HILL, WESTERN AUSTRALIA."*

Prof. H. LOUIS was doubtful whether the title of the paper conveyed the writer's meaning. The view he (Prof. Louis) held in common with most mining geologists of the present day was that all primary gold-deposits were hydrothermal deposits, and therefore to particularly describe this deposit as such was equivalent to speaking of coal-beds as of a vegetable origin. It would be of interest to know whether the writer used "hydrothermal" in this meaning, or whether he meant to describe the deposit as a geyserian deposit—a favourite explanation by Australian geologists of the origin of gold-deposits, *e.g.*, Mount Morgan, in Queensland. The author might also be asked to explain the phrase "thermal crater"—the ordinary definition of this term would be "a crater caused by heat"—did the writer mean a crater caused by volcanic action or by a geyser?

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* *Trans. Fed. Inst.*, vol. xiv., page 89.

DISCUSSION ON MR. H. D. HOSKOLD'S "NOTES UPON FOREIGN MINING LAWS AND ADEQUATE AREA FOR MINING CONCESSIONS."*

Mr. H. D. Hoskold wrote that an error had been discovered in the fourth line of paragraph three, from the bottom of page 171. The 10 years existing in that line was intended to read 1 year, as was exhibited in the descriptive heading of column 9, in Table IV. The figures at the place and page indicated should read as follows:—

"Also, 4,800·000000 × 1 year ÷ 0·052093 ounces per cubic metre = 92,142·898277 metres, or the length required under the conditions for a concession, with a width of 1 metre: but as the auriferous deposit is estimated at 2 metres in thickness, we also have 92,142·898277 ÷ 2 = 46,071·4491385 metres in length for the auriferous mining concession."

Further, in Figs. 1 and 2 (Plate VII.), the words "lengths in varas" should be taken to read "depths in varas," and in Fig. 3 (Plate VII.) the words "lengths in metres" should read "depths in metres," for the reason that in each case these lines are perpendicular to the surface or horizontal line, and consequently would represent the variable depths of shafts required to intersect the mineral veins at the deep boundary-line of each concession, the mineral vein or veins in which are found under the scale of inclined angles assigned.

The following paper by Mr. Walter Merivale was read on the "Occurrences and Mining of Manjak in Barbados, West Indies":—

* *Trans. Fed. Inst.*, vol. xiii., page 160.

OCCURRENCES AND MINING OF MANJAK IN BARBADOS, WEST INDIES.

By WALTER MERIVALE, Memb. Inst. C.E., Memb. Inst. M.M.E., etc.

Manjak is the local name for an asphalt. It is one of the many bitumens that the modern demand for insulating-material, varnishes, waterproofs, etc., has called into the market. Manjak is of two kinds, distinguished by buyers as the Emtage and the Merivale manjak, from the names of the producers. The first is fully equal to the second for certain purposes, but it cannot be so effectively used in the higher priced manufactures, for which the Merivale quality is in demand.

The meaning of the word *manjak* is obscure. Sir Robert Schomburgk, in his *History of Barbados*, quotes a reference to it in an old book of voyages, where it is called *mountjack*, but that name seems to throw little light on the origin of the word. Barbados was never the property of any European nation but the British, and manjak is purely a local term, so that the meaning of the word must be sought in the English language, unless it can be traced back to the Caribs.

About 6 or 8 years ago, the then manager of the Barbados railway tried to turn manjak to account as a fuel by compressing it into blocks, after mixing it with various substances. His efforts were not successful, and, when the author succeeded him as manager of the railway, the use of manjak as a fuel had long been abandoned. No other use for it was known, and all interest in the mineral had faded away. Mr. C. J. Greenidge, however, had sent samples to New York, and it was these samples, probably, that attracted an enterprising gentleman, Mr. Pinny, to the island, who, arriving when the author had been here about a year, represented to him that he was part proprietor in a fuel company in Boston, which owned large tracts of peat, and that he desired to acquire all the asphalt-deposits of Mexico, Venezuela, and the West Indies. The author's attention being thus directed towards manjak as a source of traffic for the railway, he took some pains to look into the matter, with the result that he found that the mineral occurred in the Scotland district in pockets, apparently in no great number and of no great size, and in a manner difficult of identification. There did not appear to be much traffic for the railway in this product. But the question how

the pockets came to be where they were could not be dismissed hurriedly. Consideration of the subject suggested that the mineral found in pockets must have been broken off a main body, and the frequent occurrence of landslips in the Scotland district, where they were found, supported this theory. Later, a vein was pointed out in another district, where the ground was not disturbed by slips. This vein showed strong indications of having been thrust upwards from below.

Once satisfied that manjak occurring in pockets was an accident, and that it originally appeared in veins, it was not difficult to perceive a very strong probability that the veins were merely indications of a much larger mass below, and that in fact they all proceeded from one and the same source; and, further, that the source of the Barbados manjak might very possibly be also the source of its relative the Trinidad lake-pitch. Some corroboration of the theory that the Barbados veins were connected was afforded later by the fact that they generally strike north-north-west. (The veins of gilsonite in the Vinta Reserve, U.S.A., strike in the same direction. Has this any connexion with the earth-crinkle which forms the axis of Northern and Central America?)

The author now began experiments to ascertain whether after all this mass of combustible could not be used for fuel on the railways, and in sugar-making. It soon became apparent that the right method of burning it was to take advantage of its extreme friability, grind it into fine dust, and inject it into the furnace with a jet of steam. This system was applied with success to a locomotive, a steam-launch and a shop-engine boiler, but it was difficult to introduce it among the sugar-factories on account of the initial expense (£20) of putting up the apparatus. Dusting the powder on to the megas, or crushed canes, however found favour amongst the planters quickly, and a business was also begun with small bricks of lime and manjak-dust made into mortar and allowed to set. The author still uses these bricks at the mines, but the supply of refuse is too small to admit of their being sold. After some months' trial of manjak as a fuel on the railway, the author decided to abandon it for several reasons, one of which was that a market had been discovered for the mineral, which sent the price up 100 per cent.

Before proceeding to describe the manner of mining for manjak, it will be well to say a few words about the geology of Barbados.

Barbados is a coral-island, one of the few, if not the only one, that can boast of exhibiting seven distinct periods of elevation in seven distinct terraces of coral. The earliest geological history of Barbados is

found in the Scotland shingles or sandstones, which from their coarseness denote their deposition in shallow water. Above them comes a deposit of oceanic ooze, consisting both of radiolarian and of infusorial earth, which is taken to indicate that the Scotland formation sank to a depth of 6,000 to 12,000 feet at a time when there was a connexion between the Pacific and the Atlantic Oceans. The evidence on this point is found by Messrs. Jukes-Browne and Harrison in the fact that radiolarian earth has been found in the Pacific Ocean, but not in the Atlantic Ocean, and that both radiolarian and infusorial earths occur in the oceanic deposits of Barbados. Without denying the accuracy of their conclusions, it may be worth noting that the fact that radiolarian earth has not yet been found in the Atlantic Ocean is not a proof that it does not exist there.

The Scotland shingles now began to rise again, bringing with them the oceanic deposit, on which, as they rose, the coral organisms built and died until the island reached its present form.

The Scotland formation contains also a blue clay,* sometimes interstratified with the sandstone—as in the Emtage pit at Bissex Hill—at other times below it, and, in the Conset district, where the Merivale mines are situated, there is no sandstone, but the blue clay underlies marl, calcareous sandstone and infusorial earth. It looks as if the blue clay had been deposited before the sandstone, which would mean a period of depression anterior to the deposition of the Scotland shingles. On this point, the author's mind is not clear, but it is certain that the blue clay is the lowest formation in which he has yet found manjak, and he believes that the blue clay has not yet been pierced in any part of the island.†

Messrs. Jukes-Browne and Harrison, in their pamphlet on the geology of Barbados, speak of bitumen and of petroleum occurring in a certain formation above the blue clay. These writers do not seem to have perceived that the source of these minerals was very much farther down than any borings have yet reached—unless we take into account those of the new West India Oil Syndicate. Manjak they were content to regard as an isolated deposit occurring here and there. The truth appears to be that there is beneath the island an enormous reservoir of liquid bitumen which is still trying to force its way to the surface. In the Conset district, there is a

* The blue clay contains 30 per cent. of iron, and the blue colour is said to be due to its presence.

† The author has been informed by an old resident, since this paper was written, that the blue clay was pierced by a well which he had dug, and that very hard rock was found below it.

hill, or rather a piece of the cliff, about 300 feet long, on the coast, called Burnt Hill, which is described by them as being impregnated with bitumen. Impregnated it certainly has been, but the impregnation took place very many feet below the level it at present occupies, and before it was thrust up through the calcareous sandstones and marls. These still stand on either side of it in alternate strata, from 3 to 12 inches thick, exposed on the face of the cliff, and rapidly and more rapidly inclined upwards as they near the intruded mass of shale. The shale, moreover, shows no stratification, but is simply a huge mass. The author has sunk shafts on both sides of it and found it below the marl. This shale, or bituminous clay, has the following analysis :—*

Moisture	7·52
Ash	76·19
Carbon	14·32
Hydrogen (not included in moisture)	1·05
Oxygen, etc.	0·92

As the shaft increased in depth thin veins of hard manjak were found, and others of liquid manjak, and of semi-liquid manjak. In the Conset district, the coral-capping has been removed, and the manjak exposed in more than one spot.

When met with, some way below the surface, the blue clay is soft and treacherous, the fissures, which divide it up into a million blocks, contain bitumen or water, and the blocks slide from their places as soon as the miner's pick removes the supporting rock or manjak from before them. Higher up, the blue clay seems to be almost a different formation, and is as hard as rock, not unlike chalk, and crossed and recrossed by thin streaks of manjak and of gypsum. Large quantities of iron pyrites are also found here and there in it, in nodules and in very thin veins.

The manjak-veins are thrust up through all the formations except the coral, which probably indicates that the intrusion occurred before the coral was formed, or it may mean that it occurred after it was formed, but was unable to get through it. In the latter case, however, the ends of the veins would be flattened out against the bottom of the coral, instead of ending in thin streaks in the softer lower formation.

The rain having washed away this lower formation after the removal of the coral-cap, the thin outcrop is exposed, and at times a stream, cutting its way down a hillside, carves out a piece of the vein that crosses its path, leaving exposed a section of the vein on each side of the gully; or the waves eat away the cliffs, and exhibit the cross-section of a vein running out to sea.

* The author, by a crude distillation, produced 30 gallons of oil per ton of this shale.

It was upon one of these stream-exposed veins that the author began work just 2 years ago, and it is from this vein or pocket, as the geologists are understood still to call it, that he has extracted over 2,000 tons. In it can still be shown indications as favourable as those which caused the writer to commence operations. Want of capital forced him to hew wherever the vein was wide enough when the mine was first started, but now that matters are more settled a better method is being adopted in his new mines.

In sinking a shaft for coal, the engineer must prepare for the passage of several hundred tons a day, but with manjak a hundred tons a week is sufficient for the market, so that a shaft that is wide enough for pumping, ventilation, and the slow passage of buckets is all that is required.

In the Merivale mines, the standard type-shaft has been fixed at 8 feet by 6 feet, divided across its greater length into three divisions, a small one for the ladder-way, and two larger ones for pumps and buckets. The two buckets, which measure 26 inches in diameter by 2 feet deep, occupy the central division which is divided by boards into two equal tubes, and the pumps are placed in the end division. The southern and the western sides of the shaft are continued upwards by boarding for a height of 10 feet, where is the stage on which rests the crab, and where later on will be the large pulley-wheels. The division between the pumps and the buckets is continued by boards also up to this staging, and is carried down to within 10 feet of the bottom of the shaft. The prevailing wind being from the north-east, it blows down the bucket-division and up through the pumping-division, or, if it shifts to the south-east, the direction of the air-current is reversed. Should the current blow from the east a door can be closed on the pumping side. But, as a matter of fact, the wind seldom varies more than a point or two from north-east, and if it varies too far, or drops altogether, the mere division down the shaft is sufficient to set up some ventilation.

In sinking a shaft through hard bituminous clay (shale ?), it is found that one man can hoist in one ascending and one descending bucket, of the dimensions just given, as much as two men and a boy can dig and fill below, in a shaft 8 feet by 6 feet, down to a depth of 50 feet. The cost is 4s. a yard exclusive of water and timbering. The timber used down to that depth is pitch-pine joists 6 inches by 6 inches, with 1 inch spruce-boards for lagging, the pitch-pine frames are placed 5 feet apart, and have 4 inches by 4 inches vertical struts between them at the corners. It must be remembered that the divisions in the shaft mentioned above prevent any timber from having a span of over 3 feet.

In No. 2 shaft, which is now 140 feet deep and in very soft watery clay, frames 8 feet by 8 feet are used, otherwise the dimensions and type are the same.

An 18 inches-gauge tram is provided at the top of the shaft to lead the spoil away, but it is difficult to persuade the labourers engaged on this work to use the rolley : they prefer dumping it on the ground, and then carrying it away in baskets on their heads. The form of rolley used is perhaps worth mentioning. The bottom is sloped, like a gable roof, on the two sides and the front end ; and the sides lift up, so that the earth runs down the sloping bottom in front, and on each side. As nearly all the plant at the mines was necessarily made by the author, simplicity of construction was aimed at.

The water is got rid of chiefly by bailing, but there is a steam-ejector, which with 58 lbs. steam works well enough up to 40 feet. Steam, though more expensive than hand labour, can be better depended on for continuous work : especially on Sundays, when it is very hard to get the negro labourers to work.

The pumps in use in Nos. 1 and 2 pit (which are the original workings) are : a hand-pump, at the bottom, which sends the water through a 1 inch pipe about 60 feet to the pulsometer, which sends it another 60 feet vertical, and about 100 feet horizontal to the main sump-hole in No. 2 shaft, where a direct acting steam-pump takes it 100 feet vertically, and 60 feet horizontally, through a $1\frac{1}{4}$ inches pipe to bank. From this statement it is apparent that the quantity of water to be dealt with is not large. These pumps—the direct-acting pump and the pulsometer—are not so economical in steam as other kinds, but they have the advantage, especially the pulsometer, of few working parts ; and the pulsometer has the further advantage that, when once set going, it will continue to work, unless a bit of manjak gets into the ball.

The shaft having been sunk as near to the vein as circumstances will permit, galleries are driven from it every 40 feet to cross-cut the vein, and from these cross-cuts again other galleries are driven at right angles into the vein itself. As the gallery proceeds in the manjak, a fresh man is set to work at the beginning of the working to cut out another 6 feet of depth, and behind him starts another, so that the vein is worked out in steps. Care is taken to put the timbers in vertical lines, one frame over the other. These frames consist of 2 uprights, 6 inches by 4 inches, kept apart by struts, 6 inches by 6 inches, every 6 feet. As rubbish accumulates, the struts are boarded over with 2 inches spruce planks, and the rubbish is packed away on these platforms, care, how-

ever, being taken to leave horizontal spaces 6 feet high where the cross galleries come, and vertical spaces every 50 feet or so for purposes of ventilation, hoisting manjak, ladders, etc. Packing the rubbish back into the hollows excavated has several advantages. It is cheaper than taking it right up to bank, it assists in keeping the walls apart, and it prevents falls of roof and sides from injuring the men below. The veins vary seldom more than 5 degrees from the perpendicular. When the walls are wet, or there is much bitumen in the fissures, a lagging of 1 inch spruce boards is put in behind the frames.

In the No. 2 shaft, several attempts have been made, at a depth of 140 feet, to drive a gallery to the vein, but all trials have failed so far, as the blue clay is so soft and wet, and is continually pouring in under the bottom frame of the shaft. Efforts are now being made to cut into it from another gallery where the distance to be driven is less.*

As the mineral is excavated, there frequently is heard a hissing sound of gas and water escaping through the walls; the gas burns with a blue flame when ignited, but the quantity is not great, and the workings are in most cases so lofty that there is not much danger to be apprehended from this source. Safety-lamps were used at first, but the dust from the manjak coated the glass with varnish, and clogged up the gauze, so that the men used to take off the shades to enable them to see, and, finding that no ill effects have followed from this practice, common lamps, burning colza oil, have been introduced, and have now been used for 18 months without an accident. Frequently, as the manjak falls before the pick, a quantity of dust falls down over the lamp, and becoming ignited, forms a brilliant cascade of yellow flame. One would expect the cloud of impalpable dust which fills the air in the workings to explode, but it is evident that the right proportions of air and dust have not yet existed, for no explosions have, so far, taken place.

In the gilsonite mines, in Utah, the dust is found to be injurious to the lungs of the workmen, and they are provided with respirators.

Since the author started his mines a good many people have followed his example, but with the exception of Mr. Emtage, and Mr. Howe, an American mining engineer, it does not appear that any have achieved success. This may possibly be attributed to an absence of knowledge of mining and of geology, which has led many sanguine prospectors to follow up promising indications in the landslips of the Scotland district,

* Since writing the above this has been successfully accomplished, exposing a vein over 8 feet wide.

when, after spending all their money, they have discovered that they had been working on a broken-off pocket. That the island is rich in manjak seems now to be demonstrated, but the main body has not been met with at 300 feet from the surface, and the author is of opinion that it may not be met with within ten times that distance, but that the first man who gets to it will make a fortune. It is not by any means impossible that this main body is still fluid, a huge underground pitch lake.

The following are analyses of Merivale manjak and of Trinidad glance-pitch :—

	Merivale Manjak.	Trinidad Glance-pitch.
Specific gravity	1·123	... 1·139
Melting point	420° Fahr.	... 360° Fahr.
Matter soluble in carbon bi-sulphide	97 per cent.	... 88 per cent.
Ash	2·32 ,,	... 7·44 ,,
Ash, colour	reddish	... greyish.
Loss on heating	2·61 per cent.	... 9·4 per cent., after heating to 500° Fahr. for 2 hours.
Iodine absorption	42·2 ,,	... 42·0 per cent.
Organic dust	0·68 ,,	... 4·56 ,,

The PRESIDENT (Mr. George May) remarked that there would be a certain amount of danger in working the bitumen, especially if the galleries were further extended, as the dust from the manjak would fall and would be easily ignited.

Prof. H. LOUIS said that some few years ago there was a serious explosion from grahamite, which was a similar substance.*

Mr. T. Y. GREENER remarked that the floating dust would be a danger to the workmen's eyes. In the filling of pitch at the Peases West Bankfoot tarworks the men were very often incapacitated, owing to the effect of the dust upon their eyes, and it was necessary for them to wear close spectacles.

Mr. W. COCHRANE asked what was the average width of the vein of manjak, and whether it was found in large masses, or whether it was interspersed with rock which had to be broken up before the manjak was obtained. He also asked whether the pockets referred to in the paper were connected by veins with other pockets.

* *Trans. Fed. Inst.*, vol. x., page 560.

Prof. H. Louis suggested that information might also be given as to the direction of dip, and a section of the ground in which manjak was found. He knew of some similar substances, such as gilsonite, grahamite, albertite, and stellarite, the latter of which was worked in Nova Scotia, and there was a whole series of bitumens known in different parts of the world, which occurred in pockets or bunches or veinlets. Bitumen was found in the Mountain Limestone of Derbyshire, and he had seen bitumen-mining on a fairly large scale in some parts of Eastern Russia, where the mines were being worked in beds of Lower Carboniferous age. It occurred as a hard mass in streaks, pockets and veins, in certain definite horizons, as though the bitumen in a plastic state had filled up all the cracks and fissures. He would like to know the writer's reason for thinking that manjak came from a large internal deposit.

The President moved that a vote of thanks be accorded to Mr. Merivale for his interesting paper, and this was unanimously agreed to.

DISCUSSION ON MR. R. F. PERCY'S PAPER ON "THE DETERMINATION OF, AND USE OF, THE MAGNETIC MERIDIAN IN MINE-SURVEYING."*

Mr. G. C. Hooper (Klerksdorp, Transvaal) wrote that although Mr. Percy's method of fixing on a magnetic base from which to proceed with a mine-survey (surface or underground) was an improvement on the common method of choosing any two points, such as junctions of fences, shafts, etc., it was not an absolutely reliable method, because, in addition to the points being incorrectly surveyed and plotted, there was also the liability of error due to local magnetic attraction. This latter source of error was more prevalent in metalliferous than in coal-mining districts, and might be seen and measured by staking out a straight line and reading its magnetic bearing at different points. The variations shown in Mr. Percy's paper† were probably due to local attraction, and there was, consequently, no certainty that the mean bearing of 67° 57′ 0″ was more nearly correct than the bearing *A*, *C* or *D*. In laying down the meridians on the plan as described by Mr. Percy, there was always a variation or difference in them, and the difficulty was to know which to adopt (the average being known to be incorrect). If all the work in connexion with the process was made with equal care it could not be argued that any one of them, or

* *Trans. Fed. Inst.*, vol. xii., page 581. † *Ibid.*, page 583.

the average bearing, was more nearly correct than another. Possibly this error might be small, but to it must be added errors due to incorrect surveying and plotting, expansion and contraction of plans, impossibility of close reading of an ordinary compass, and of directing the instrument exactly in the line of the points at each magnetic bearing read. These notes also referred to the method of obtaining a base-line by reading the magnetic bearings of one or more of the surface-survey lines, and he (Mr. Hooper) could see no difference between this method and that described by Mr. Percy. A survey carefully made with the magnetic needle might be very nearly correct, and if made in relation to some lasting surface-object or based on the true north line was useful for future reference. For extracting the due quantity of minerals on boundaries, however, and for use in determining a base for the survey, the needle was not sufficiently accurate, and should be discarded. Although an accurate survey cost more than a rough survey, it was apparent, and was generally conceded that the accurate survey was the preferable one, and this was chiefly due to the fact that both lives and money were frequently lost where incorrect and imperfect plans were used. It was the unfortunate fact that the danger and loss was not immediate that favoured the production of inaccurate plans. The average surveyor was incapable of making an accurate survey, and never would be able to correctly determine the true north line, nor to certify that his plans were correct. For these reasons, he (Mr. Hooper) thought that it would be worth the Government's consideration to make the trigonometrical points of the Ordnance Survey available for use, and issue to applicants the calculated co-ordinates of these points. The principal advantages resulting from this information would be that the most delicate and difficult part of the survey would be made by competent surveyors; that all surveys would originate in the true north line as determined by the Ordnance Surveyors; and that the carefully measured base-lines of the Ordnance Survey would be available for use (by calculating the distance between two suitable trigonometrical points from the co-ordinates). If the mine-surveys were made with proper instruments, further advantages were:—All stations of surface and underground surveys, and consequently the details of both, could be referred to the zero point of the Ordnance co-ordinates; the surveys could be conveniently recorded in a book kept for the purpose; future accidents and damage to property would be reduced; and there would be no excuse for inaccurate plans.

Mr. R. F. Percy wrote that he had also occasionally found differences in magnetic readings at different points in the same line,

and had, in consequence, adopted the theodolite-dial method of comparison to detect and avoid misleading bearings. The method was intended for revision of old meridians, rather than for application to new plans, and would be found of service as a means of verifying surface-details. He admitted that Mr. Hooper's objection to taking the mean of several figures was not unfounded, but in averaging, he only followed the common practice of scientific observers. Perhaps it would be wiser to reject the bearing D, as it clearly differed from A, B and C, and was probably not normal, and thus increase the mean to 67° 58′; but he thought that a question of 0° 1′ in the direction of an ever-swinging line was of no moment, and he did not mean to imply that any magnetic survey could give precise and accurate results. Referring to the remarks on the Ordnance stations, if the information were supplied, the longitude above ground might be calculated, but the problem of transferring it to a deep mine would still remain unsolved.

DISCUSSION ON MR. HALLIMOND'S "NOTES ON THE COAL-SEAMS OF THE TRANSVAAL."*

Mr. W. T. Hallimond, in reply to Mr. Frank Simon's remarks, wrote that he did not state that "duff was useless," but that as yet there was no demand for it. The small coal obtained from some of the more bituminous seams, in the Middelburg district, coked fairly well, but would give a still greater percentage of good coke if properly treated by crushing and washing. He did not claim that the Rand collieries' appliances effected a saving of 1s. per ton over any "well-equipped" colliery in the Transvaal. He said that "the combined saving amounts to 1s. per ton over the old systems of banking out and bagging." Both Brakpan and the Cassell collieries had the old modes of banking out and bagging in use at the time of his paper being written. The shoots for bagging coal at the Rand collieries were different from those at other collieries, inasmuch as the coal after falling over the end of the picking-belt found its way by gravitation into the bags, whereas by the old system at the Brakpan and the Cassell collieries, the coal, after leaving a jigging perforated plate, accumulated in a large heap on a flat tray, from which it had to be shovelled by hand into the bags. There were no "new features" in the method of dumping at the Rand collieries, but he would suggest to any colliery manager putting up new plant, that elevating to the top of dump-heap level, by bucket-elevators, would

* *Trans. Fed. Inst.*, vol. xiii., page 372; and vol. xiv., page 131.

be more economical than hauling trucks up to that level by either animal or mechanical power. He could not compare costs with the Cassell or other colliery as he had no others in his possession, but he had every opportunity of comparing the old and new methods of banking-out, screening, sorting, and bagging.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

STUDENTS' MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.
FEBRUARY 12TH, 1898.

MR. H. D. COWAN IN THE CHAIR.

DISCUSSION ON MR. T. E. PARRINGTON'S PAPER ON "ECONOMICAL COMBUSTION OF COAL FOR STEAM-RAISING PURPOSES."*

Mr. T. E. PARRINGTON agreed with Mr. R. R. Simpson that the percentage of ash in the coal was somewhat large, but the results were those of an analysis of Busty coal from the Durham district. He did not think that Mr. Simpson had fully understood that the paper was intended to show that the "usual" was not always the "correct" allowance of air, and although 18 to 24 lbs. of air per pound of coal would no doubt usually be admitted he did not think that the results would be so good as with 15 to 20 lbs., according to the method of firing. With a mechanical stoker 15 lbs. of air should be an ample supply, and when firing by hand this quantity of air would be increased in the inverse proportion to the capabilities of the firemen, and the carbon-dioxide test would show their qualities or defects. The heat lost in maintaining the water in a state of vapour was more than counterbalanced by the heat created by the combustion of sulphur, and as both were small quantities they were both omitted. The selling price of 6s. per ton of coal was taken as a fair average value, and if the coal were more valuable the saving would be greater, and *vice versâ*, as the writer had not intended his paper to apply only to collieries. He (Mr. Parrington) had purposely omitted the extra labour entailed by the use of an extra boiler, as he considered that none would be required. At Wearmouth colliery, it was found that 1 man and 1 boy could easily manage 4 Lancashire boilers; in another case, the proportion of labour was 3 men to 4 boilers, and the coal-consumption was just double the amount used per boiler at Wearmouth. A series of tests at

* *Trans. Fed. Inst.*, vol. xiii., page 384.

Wearmouth colliery had shown an average evaporation of 9 lbs. of water per lb. of coal, and although he had not any figures for the other range of boilers, he considered that he was fairly safe in stating that they could not equal, much less excel, the results at Wearmouth colliery. He agreed with Mr. Simpson's last remark, that "by doubling the steam-pressure the same amount of energy can be developed by using only one half of the fuel." The owners of Wearmouth colliery were preparing to work their engines at a pressure of 120 lbs. per square inch at the Hylton winning.

The CHAIRMAN stated that at Elswick colliery a number of egg-ended boilers had been replaced by Lancashire boilers, and during the first year the cost of the new boilers had been repaid out of the value of the decreased quantity of coal consumed.

DISCUSSION ON MR. J. CADMAN'S "NOTES ON REARER WORKINGS."*

Mr. R. R. SIMPSON enquired whether any attempt had been made to work the Hams and Rough Seven Feet coal-seams when they were separated by 12 feet of rock. Could Mr. Cadman give any reason for the spontaneous combustion which seemed to occur so frequently in the North Staffordshire coal-mining district?

Mr. JOHN CADMAN said that of the two seams mentioned by Mr. Simpson, the bottom seam (Hams) was usually worked first, and the other or what could be got of it afterwards. The Rough Seven Feet seam was superior to the Hams, and it sometimes happened that the Hams coal was not worked. Spontaneous combustion (in the Bullhurst seam) usually occurred in districts where there was a rider coal or bituminous shale (hussel) underneath the seam, containing finely divided pyrites, and also highly oxidizable bituminous matter, and it was therefore probable that this shale was an important agent in the production of spontaneous combustion.

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* *Trans. Fed. Inst.*, vol. xiv., page 392.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

TWENTY-SIXTH GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
FEBRUARY 22ND, 1898.

MR. A. M. CHAMBERS, PRESIDENT, IN THE CHAIR.

The report of the delegate (Mr. L. L. Belinfante, M.Sc.) representing the Institution at the International Geological Congress, was communicated as follows :—

REPORT OF THE DELEGATE TO THE INTERNATIONAL GEOLOGICAL CONGRESS.

LONDON,
January 26th, 1898.

GENTLEMEN,—The Seventh International Geological Congress was opened at St. Petersburg, in the great hall of the Zoological Department of the Academy of Sciences, on Sunday, August 29th, 1897, at 1·30 p.m., by His Imperial Highness the Grand Duke Constantine Constantinovich, who delivered an inaugural address. One of the speakers who followed, His Excellency the Minister of Agriculture and Domains (Mr. Yermólow), drew attention to the fact that this year the Russian Geological Surveyors would begin the detailed study of the auriferous regions of Siberia, and that the Imperial Government had found it necessary to treble the staff of the Geological Survey. The meeting then proceeded to the nomination of the officers of the Congress, chosen from among the representatives of the several nationalities, and your Delegate had the honour of being selected as one of the seven Secretaries.

On Monday morning, August 30th, the first business meeting of the Congress was devoted to the discussion of stratigraphical nomenclature, and the following resolutions were adopted :—

1.—The Congress is of opinion that the historical method of classification must be maintained, while striving to approximate it more and more to a truly natural classification.

2.—The Council are hereby requested to nominate a Committee for the study of the principles of classification in the spirit of the preceding resolution.

At the afternoon meeting, Prof. Stanislas Meunier, of the Paris Museum of Natural History, showed his method of imitating on a small scale the orographic structure of Europe. An indiarubber sheet, if allowed to contract upon itself into a hemispherical shape, and covered with a thick coating of plaster, soon showed rugosities and depressions in this crust which followed precisely the course of terrestrial phenomena on a large scale, in arising later and later the farther they were from the pole. Thence he inferred that if our globe possessed the contractility characteristic of indiarubber, the relief-map of Europe would be exactly what it is.

Prof. Sacco, of Rome, then drew attention to his orogenic model of the globe, which he had presented to the Congress. He starts from the postulate of the original state of igneous fusion of the mass of the earth and its subsequent cooling by radiation, accompanied by a progressive reduction in volume and diameter. This is still going on, the earth's crust is ever wrinkling more and more, and mountain-building has been continuous from the Secondary period down to the present time.

Prof. Prinz, of Brussels, described his experiments on plastic materials, wherein, by simultaneous torsion and pressure, reliefs similar to those seen in actual maps were produced.

Communications on the study of glacier-motion followed.

On Tuesday, August 31st, the members of the Congress proceeded, by invitation of His Majesty the Emperor, on a special steamer down the Neva to Peterhof, one of the summer residences of the Court, where they were entertained at luncheon, and were enabled to visit the Imperial stone-cutting and polishing factory in the park. The excursion afforded us an opportunity of noting the activity of the Government shipbuilding-yards. Several battleships and cruisers were seen in various stages of building and fitting, while under the long grey walls of Cronstadt a powerful squadron lay at anchor. The river was crowded with merchant shipping, and at the quays steam-colliers and other vessels were busy discharging and reloading cargo.

On Wednesday, September 1st, the first item in the programme was the International Geological Map of Europe. The Committee were enabled to give an encouraging report of the progress of the work, a large number of sheets having been published.

The discussion of stratigraphical nomenclature was then resumed, and the following resolutions were adopted:—

1.—The introduction of a new stratigraphical term into international nomenclature must be based upon a well-recognized, peremptory scientific necessity. The application of every such new term must be accompanied by clear definitions of the lithological and palæontological characters of the deposits to which it applies, and must be founded, not upon the facts observed in a single section, but upon data collected from a more or less considerable area.

2.—Terms applied to a formation in a particular sense cannot be again employed in another sense.

3.—The date of publication determines the priority of stratigraphical names given to one and the same series of beds.

4.—For the smaller stratigraphical subdivisions, sufficiently characterized by palæontological appellations, it will be preferable, when introducing new names, to base these on the most important palæontological characteristics of the strata. Geographical or other names should either be used, only for groups of some importance which include several palæontological horizons, or, when it is impossible to give a palæontological appellation to the subdivision.

5.—Names which are ill-constructed from the etymological point of view may be amended, but not entirely abolished.

At the afternoon meeting, Prof. Walther, of Jena, read a paper on the classification of rocks based on their mode of origin. He divides all rocks into four main groups:—(1) mechanical, (2) chemical, (3) organic, and (4) volcanic.

Prof. Stanislas Meunier summarized the experiments whereby he had reproduced the mineralogical composition and structure of the matrix-rock of the platinum of Nijni Tagilsk (Ural). He showed that all the minerals: olivine, pyroxene, ferriferous platinum, chrome iron, and oxide of iron, found in this rock can be reproduced, in a porcelain tube heated to redness, by the mutual reaction of carefully selected ingredients. The chemical conditions appear to be much the same as those which lead to the constitution of meteorites, and which at the present time are at work in the solar photosphere, where the luminosity follows upon the deposition of a sort of "hoar frost" resulting from the condensation of vapours cooled down to the necessary temperature.

General de Tillo described the barometric observations which prove the existence of a depression in the centre of the Asiatic continent. He then referred to the magnetic anomalies observed in Central Russia. These show that the horizontal strata which condition the vast plains of that region mask great disturbances in the rocks deeper down below the surface.

Mr. Lebedinzew reported the results of recent explorations in the Gulf of Karabugas (Caspian Sea). The bottom of the gulf is covered with gypsum-deposits, overlain in the middle of the area by deposits of Glauber's salts. In connexion with these unique occurrences attention is drawn to the chemical composition of the waters of the Caspian, which are very rich in sulphates. The relation between the proportion of sodium chloride and that of magnesium sulphate is there expressed by 2·6 : 1, while in oceanic waters it is 11 : 1.

On Thursday, September 2nd, the members of the Congress, on the invitation of the Senate of Finland, travelled by special train through Viborg to the Imatra Waterfall, where they were entertained at a great banquet. At this spot, there is an opportunity, unequalled elsewhere in Russia, for the utilization of water-power, and its comparative proximity to the capital of the empire suggests that that opportunity cannot long be overlooked.

On Friday, September 3rd, the Congress adopted Prof. Andrussow's proposal, backed by the signatures of some of the most influential scientific men of all countries, to establish an International Floating Institute for the study of the fauna, flora, physics, and chemistry of the deep sea. It was resolved to appeal for support to the various governments.

Prof. Gaudry's invitation to hold the Eighth International Geological Congress at Paris in 1900 was enthusiastically accepted.

Various papers of palæontological interest were read at the afternoon meeting.

On Saturday, September 4th, the following proposals were laid before the Congress in the name of a meeting held by forty-two petrographers:—

(1) It is not desirable, in view of the present rapid development of the science of petrography, to attempt to establish definite principles of classification of rocks by a resolution of the Congress.

(2) To attain the simplification of petrographic nomenclature demanded by geologists, it is necessary to define with greater precision than has yet been done such general terms as are required in geological mapping.

A Committee was appointed to study the question of the establishment of an international journal of petrography.

The papers read at the afternoon meeting dealt chiefly with palæontological questions.

On Sunday, September 5th, the closing meeting of the Congress was held, and public expression was given to the gratitude felt by all foreigners present for the magnificent hospitality lavished upon them by the Russian Emperor and his subjects in every rank of life.

Two representatives of each nationality were personally received by the Emperor and Empress at Peterhof; brilliant receptions were given at the Marble Palace by the Grand Duke Constantine and the Grand Duchess Elizabeth, at the City Hall by the Mayor of St. Petersburg, and at his official residence by the Minister of Agriculture.

The Congress was preceded by excursions in Finland, Esthonia, and the Urals: in the latter, we had the opportunity of visiting gold, platinum, copper, manganese and iron-mines, together with mineral mines and asphalt-deposits. It was followed by excursions down the Volga, through the Donetz basin (collieries) and Kiev, all converging on the Caucasus. At Baku, we visited the oil-wells and the petroleum-refineries of Messrs. Nobel & Co. The refineries are equipped with excellent plant, and appear to be worked on principles of strict economy. Part of the refuse is further worked up at other refineries belonging to the same company, near Tzarítzin on the Volga, which I had the opportunity of visiting. Such oil-refuse as does not pay to refine is carried, in barges and by rail, right up into the Urals, where it is used as fuel in many of the iron-works. The river-steamers on the Kama and the Volga, and the locomotives on the great Trans-Siberian railway also use oil as fuel. Further excursions were organized to Mount Ararat and the Crimea, and these formed a fitting climax to what may be regarded as perhaps the most successful session ever held of the International Geological Congress.

I am, Gentlemen,
Yours faithfully,
L. L. Belinfante.

The President (Mr. A. M. Chambers) moved a hearty vote of thanks to Mr. L. L. Belinfante for his interesting report on the work of the Seventh International Geological Congress, and congratulated him upon his being selected as one of the International Secretaries.

The motion was cordially approved.

Prof. Henry Louis read the following paper on "Technical Education in Mining":—

TECHNICAL EDUCATION IN MINING.

By Prof. HENRY LOUIS, M.A., A.R.S.M., Etc.

So much has been written and said of recent years upon the subject of technical education in general, and upon the technical training of miners in particular, that another paper on the same subject may seem somewhat superfluous; seeing, however, the widely divergent views that have been expressed and the absolutely opposite standpoints that have been taken up by so many of those who have dealt with the matter, it seems to be by no means threshed out yet, and it may not be amiss if the present paper serves to reopen a discussion upon this most important subject. It is proposed in the present paper to treat it, as far as possible, from an ideal standpoint, and to examine the principles that ought to form the basis of a sound mining education; and, whilst so doing, to avoid any reference to the methods of mining education that are actually practised in various institutions.

It is, first of all, obvious that a broad distinction will have to be made between the technical education suitable for the mining engineer, general manager, or viewer, and that suitable for the working miner which should ultimately lead him into the position of a subordinate official, rising subsequently to that of under manager, resident manager or mine captain; of course, it happens at times that a man in the latter class rises into the former, but this would be due to his individual exceptional ability, which enables him to acquire or to dispense with the education generally considered necessary for the first-named posts. It is not, however, either possible or desirable to attempt to prescribe limits to genius or to legislate for exceptions.

Taking first the working miner as we have him in this country, he should leave his Board School in the sixth, or at the lowest, the fifth standard, with the rudiments of a sound education, a knowledge of English grammar, history, etc., a decent (and often a good) hand-writing, and a knowledge of arithmetic, going, say, but little beyond decimals. He will then commence his mining career either on the surface or else as a trammer, driver, trapper, etc., underground, and thus begins his technical instruction—a very different thing from technical education—in the art of mining. At the same time he ought

to work steadily at evening continuation-classes, which will carry on his education from the point where the Board School left it. He ought to acquire facility in composition, to advance his knowledge of arithmetic, learn the rudiments of mensuration and geometry, and, if possible, also of mechanics or physical science. At the age of 15 or 16, he ought to be beginning elementary science, more especially chemistry, physics and geology, learn as much of the elements of algebra as will enable him to understand and use a formula, and as much Euclid and geometry as will enable him to grasp the elements of surveying. After two or three years more, he should take up the subjects of mineralogy, mechanics, steam, hydraulics, applied electricity and similar applied science subjects, and finally devote a considerable portion of 2 or 3 years to the theory of mining. A course of ambulance lectures and a little elementary physiology might well be introduced during the same period. Meanwhile his practical training underground will have been progressing steadily, and if fairly intelligent, active and strong, he ought also to have acquired a sufficient amount of manual skill in his work. This is a point in which British miners are rarely deficient; in comparing them with those of other nations, it is noticeable that, however backward they may be in technical education, their technical skill is generally at a high level.

By this time the miner, whose educational programme we have been sketching, should be about 22 years of age, and, if a coal-miner, he should now have no difficulty in getting his second-class certificate. At the same time, few men are fit to be placed in a position of authority underground till they are 25 at least: this is perhaps the lowest age at which a young coal-miner ought to attempt to sit for his first-class manager's certificate. His scientific work in these last three years would consist of much the same subjects as in the previous few years, only it must be of a more advanced character. It will be noticed that no distinction has been made between the education of coal- and metal-miners; as a matter of fact, the scientific groundwork of both branches of mining is identical. The differences lie in details of practice and routine, not in principles. It is one of the misfortunes of the mining industry of this country that legislation has interfered to discriminate between these two branches, and to a certain extent to compel the metal-miner to be ignorant of coal-mining and *vice versâ*. Whatever may have been the justification for the policy of enacting one law for the coal-miner and another for the metal-miner, when the Coal and the Metalliferous Mines Regulation Acts were established, there is assuredly none now, seeing that coal-mining has become actually

a safer occupation than metal-mining. The writer proposes, however, to return to this point subsequently.

There is scarcely any mining district in Great Britain in which tuition in the subjects comprised in the above outline scheme cannot be obtained, thanks very largely to the action of the various County Councils; but a rather greater difficulty is to be found in the question of examinations. Those most generally taken are the May examinations of the Science and Art Department, and some of those of the City and Guilds of London Institute, but at present neither is quite suitable to the needs of the miner, and more especially of the coal-miner. There is a certain amount of overlapping which is prejudicial, and the former examinations in particular seem to require remodelling; the writer ventures to suggest that it might be best if the Science and Art Department were to restrict itself to pure science and art subjects, leaving the applied sciences to the latter or to some similar body. At the same time, the present wide discretion ought not to be allowed to local teachers in the selection of their subjects. It is pretty well understood by now that subjects are chosen which are popular in the district, and their capacity for earning grants is looked to, rather than their utility to the students. This will necessarily be the case so long as payments are made to teachers on the results of examination, rather than of an inspection of their methods of teaching. Another most pernicious result has been the "cramming" of students with a string of words, of the meaning of which they have not the least comprehension, but which will enable them to write down an answer on any point included in the syllabus. Without wishing to minimize in any way the real good that the Science and Art Department have done for the country in the past, the writer's experience has amply proved to him that their system now requires reorganization if more harm than good is not to result in the future. What is needed is a progressive course of examinations, in which no student will be allowed to attempt applied science subjects, until he gives proof that he has mastered the elements of the pure sciences upon which the former are founded; thus and thus only can the effects of the present deplorable system of "cramming" be at any rate partially averted.

Throughout the mining districts of the country a fair and steadily increasing number of young men is to be found anxious to take advantage of the educational facilities offered to them. It is, however, most noticeable that the great mass of the mining community makes no effort to provide for itself the scientific tuition so greatly needed; in educational matters the British miner is still a baby, and requires to be spoon-fed

with science; he has not yet reached the stage of attempting to supply himself with his scientific pabulum. In strongly marked and unfavourable contrast to their fellow-workers on the Continent, the powerful and wealthy miners' unions of this country do not, so far as the writer can learn, devote one single penny of their great incomes to the dissemination of scientific education amongst their members. From every point of view this illiberal attitude is to be regretted; apart from the fact that it is surely their duty to afford facilities for the higher education in their work of the rising generation of miners, it would seem to be to the interest of the unions themselves that they should take an active part in training the more able of their members to occupy the positions of subordinate officials in mines; not only would the unions be strengthened directly in this way, but the development of thinking capacity in their members generally, which is the acknowledged result of even elementary training in science, would add greatly to the power and influence of the unions. But above all, the point which the writer has more than once had occasion to urge, must once again be repeated and emphasized, that the better education of the working miner is the best possible safeguard against accidents. There is no need to accumulate proofs of this statement, since any table of statistics of mining accidents will give ample evidence that the vast majority of them are due to ignorance or gross thoughtlessness. Fully two-thirds of the annual roll of accidents are preventable, and preventable by the training of the miner in thinking power, and in the elementary principles of science. The apathy of the miners' unions of this country towards the teaching of the sciences underlying their daily work is a standing disgrace to them and to their leaders.

Let it not be thought that too much emphasis is being laid on the importance of the scientific education of the working miner; the level of technical education needs raising, and it cannot be raised unless all ranks advance proportionately. Moreover, the future of our great mainstay, the coal-trade of this country, lies to a very great extent in the hands of our coal-miners. It is from among them that the subordinate officials of the collieries must be selected, and just as it is true that "the backbone of the army is the non-commissioned man,"* so is it certain that the working qualities of any pit depend to a very great degree upon the character of its deputies.

* The 'eathen in 'is blindness bows down to wood an' stone;
'E don't obey no orders unless they is 'is own;
The 'eathen in 'is blindness must end where 'e began,
But the backbone of the Army is the non-commissioned man!
RUDYARD KIPLING—"The 'Eathen.

Taking next the question of the training of mining engineers, we are confronted by a series of rather more complex problems. It will be gathered from what has been set down as the requirements of the scientifically educated miner, that the writer would expect the attainments of the mining engineer to be of a decidedly high order, as we may take it for granted that the mine-manager should not be inferior in technical knowledge to even the best of his subordinates. The aspect of mining engineering is changing rather rapidly; the days of small concerns, living from hand to mouth, and trusting to luck, are clearly numbered, and the mining engineer of the immediate future will be called upon to control vast undertakings depending for their profits upon a large tonnage of production, accurately calculated, and worked with the narrowest possible margin. Under these conditions it will only be thoroughly scientific administration that will be able to keep expenses below income, and all the resources of modern physical science will have to be pressed into service. Having regard to these truisms, and to the fact that custom has decided in this country that 3 years is ample for the scientific training of the mining engineer, it is obvious that the aspirant will have to come to his work exceptionally well prepared. It is possible that in time we shall come to the conclusion, as they have already done in America, that 4 or even 5 years are not too many to devote to the work of education for this most onerous profession, and that it pays to spend the longer period in preparing for the multifarious duties of a mining engineer. Here again we are hampered by the absurd legislation which considers time spent in loafing about a colliery better employed than in studying at a college. The writer does not for a moment mean to imply that all colliery pupils do idle their time away, any more than he would venture to suggest that college students invariably work hard; he is only stating the fact that the law ranks idleness in one place before hard study in another. The Coal Mines Regulation Act, or as much of it as applies to the examination of colliery-managers, most directly discourages scientific knowledge in a colliery-manager, by giving him no credit for such knowledge, and by refusing to recognize time spent in acquiring the scientific knowledge upon which his art depends, as time spent in learning that art. It would really have been difficult to have framed a more pernicious piece of legislation, or one that has been more effective in keeping scientific mining in this country behind that of others. There is no need to look beyond it for the reason of the admitted fact that we are behind the rest of the world in our technical science, and it is hard to see what it avails to give our County Councils powers to provide for technical education as

long as the law persists in handicapping those who would like to avail themselves of the educational facilities offered in such a tantalus-like fashion. The first condition needed for the higher scientific training of mining engineers is such an alteration of the law as shall bring coal- and metal-mining under the same conditions, as shall insist on a minimum of scientific training, as shall allow 3 years spent at a recognized mining college, together with the passing of examinations in science of a specified standard to rank as part of the 5 years' apprenticeship required, and as shall allow time spent underground in a recognized foreign or colonial mine to also count (possibly under certain restrictions) towards the period of apprenticeship. At the same time, the examinations and the conditions of admission to examinations ought to be made uniform throughout Great Britain. With a law thus amended, the writer would be far more hopeful of sound progress in scientific mining than he is at present.

A lad prepared to enter any mining college should have received an education such as is provided on the modern side of any good school. He ought probably to have learnt a little Latin, enough to help him to write his own language clearly and correctly; he ought to have a thorough knowledge of arithmetic, and be fairly well advanced in Euclid, algebra, and possibly a certain amount of trigonometry also; he ought to know at least one foreign language, have been well grounded in elementary mechanics, physics and chemistry, and have been taught a certain amount of drawing. The average age for admission to a mining college should be about 17, and even though this were made the minimum, no harm would result from such a step. There will no doubt be fairly universal agreement as to what science subjects should be studied at the college; the only differences of opinion will be as to the amount of each required, that is to say the minimum amount. The more a mine manager knows of any subject under the sun, the better for him; the only question is, how he can apportion his short 3 years at college to his own best advantage. The writer personally holds that he does not need to read mathematics very deeply; it is essential that he should know the lower branches most thoroughly, but he can well limit his work to the elements of the calculus and of analytical geometry. For example, in 20 years of an active and very miscellaneous engineering practice, the writer cannot remember to have come across a single problem that required for its solution any higher mathematical knowledge than a very moderate amount of trigonometry, and he has no doubt that the experience of the vast majority of mining engineers will bear him out in this view. A considerable knowledge of chemistry is required, not only because a mining engineer ought

to be able to analyse and assay for himself any unknown substance that he may come across in his workings, but to enable him to understand the sometimes complex reactions that are continually taking place in the mine, as fresh portions of mineral are exposed to the action of air and water. In the vast majority of metal-mines, the manager is expected to know how to assay the products of his mine, and though this is rarely required from the coal-miner, yet even he will be benefited by a sound knowledge of chemistry ; indeed, the writer ventures to think that the subject has been far too much neglected in this country. The success that has attended the development of the Westphalian coke-trade, for example, is largely due to the economies in coke-manufacture consequent on the utilization of the bye-products. Bye-product coke-ovens have made but very slow progress in this country, and it is perhaps fair to surmise that one factor that has told against them is that those to whom the superintendence of the coke-manufacture is entrusted, are deficient in the rather considerable degree of chemical knowledge which this process demands. In physics, the rudiments of heat and optics alone are required, whilst electricity should be thoroughly studied, especially as regards its technical applications, and the student should make himself thoroughly familiar with electrical measurements. Geology is, of course, a most important subject, stratigraphical and physical geology being the branches that need most attention ; the rudiments of lithology and palæontology are quite sufficient, the more advanced portions of these subjects being best left to specialists. On the other hand, economic and determinative mineralogy require thorough study. The mode of occurrence and distribution of the useful minerals is a special subject that must also be known thoroughly. These are all the pure sciences that are absolutely needed ; their application embraces a large number of subjects, such as engineering (including mechanics and steam), metallurgy, and the art of mining with its various subdivisions, including the dressing and washing of minerals, and mine-surveying. The latter subjects are, of course, the chief subjects that the student has to learn. Mine-surveying must undoubtedly be taught practically as well as theoretically, and a properly trained mining student ought, when he leaves the mining college, to be quite familiar with the use of all surveying-instruments and the method of executing surveys, and to need nothing except practice to make him a competent surveyor. In this connexion it may be as well to point out the great want there is in this country of any recognized examination for mine-surveyors which should set a standard of proficiency. It surely seems absurd that the Government should insist upon a severe examination for under-managers

and at the same time allow any one to practice as a mine-surveyor without any evidence of his capabilities in this respect, seeing that a blunder in surveying is just as likely to, and has only too often been known to, cause as great loss of human life as any other mistake that can be made underground ; indeed, there is this stronger reason for only admitting surveyors who have undergone some test of their proficiency, that any risks of accident due to a mine-manager's incapacity terminate with his underground career, but those due to a mistake in a survey often become operative only very many years after the surveyor himself has been entirely forgotten. The importance of employing only certified surveyors in mines has often been pointed out by H.M. inspectors of mines. Thus Mr. W. N. Atkinson, in his last report, advocates that all mine-plans should be made by certified surveyors, without recommending, however, that the certificate should necessarily be one granted by the Government.

The subject of dressing of minerals is one which, systematically studied abroad, is just as systematically neglected in this country. It requires to be treated practically, best perhaps in a small laboratory, fitted with light breaking machinery, and dressing machinery such as sieves, handjigs, spitzkasten, shaking-tables, etc. These should all be on quite a small scale, and constructed whenever possible of glass ; they should be capable of treating small quantities of mineral, say some 10 lbs. or so at a time, so as to allow the student to control a machine thoroughly, and vary all its conditions of work easily and rapidly, and yet obtain a sufficient quantity of material to enable him to test thoroughly the products obtained. Such concentrating laboratories have been brought to a high pitch of perfection in the United States, that at the Massachusetts Institute of Technology being a model of what such laboratories should be. The writer holds that the establishment of such a laboratory in the United Kingdom is one of the needs of the day ; it can hardly be gainsaid that we are behind other nations, notably the Americans and the Germans, in our knowledge of this subject, and our deficiencies in this respect are already commencing to show serious commercial results. Anyone who wants a striking object-lesson as to the extent of our ignorance, and what it means in the loss of hard cash, had better pay a visit to Nenthead, and see a foreign company working successfully mines which their English owners could not make pay, and treating with profit refuse-dumps that these same owners had left behind them ; needless to say, foreign management and foreign machinery are being employed. At the other end of England, in Cornwall, it is equally painful to note the thousands of pounds worth of tin lost annually in slimes, and to watch men working at the close of the

nineteenth century with the crude machinery invented in Germany three centuries ago. Nor has the coal-miner any better reason to be proud of himself, for when we turn to the subject of coal-washing, we shall see that even here, in this country of coal-mines, if anyone wants to erect a really complete and efficient coal-washer, he has to adopt a German or a Belgian design, because there is no English one. Scientific coal-washing is one of the main methods by means of which our Continental rivals have been enabled to carry on the struggle against us in the coke-trade, although their raw material is admittedly inferior. Few subjects, if any, are better fitted to engage the immediate attention of all our mining industries than the problem how to bring the art of dressing minerals in this country into line with the progress made by our mining rivals, and it is doubtful whether any wiser expenditure could be made than in this direction.

The most difficult question to settle, and perhaps the one in which there is room for the widest divergences of opinion, is to what extent students should themselves actually work in mines. There are no two opinions as to the need for their visiting mines and studying mining operations as practically conducted, but there are two opposite schools, each very decided in its views, one of them holding that there is not the slightest gain in a student doing any more than carefully and closely watching and studying the method in which work is carried on, whilst the other maintains that it is impossible to learn mining without actually doing the work. The writer has no decided bias towards either opinion, but recently had occasion to make a rather wide investigation of the views held on this point in different quarters, and, though he prefers not to name the various authorities who have been good enough to supply him with information, he may say that in America the first-named and in Germany the latter views are prevalent, whilst in this country both schemes of education are adopted.

The advocates of actual work in this country are mostly to be found amongst metal-miners, ore-mining students often working in mines, whilst coal-mining students or apprentices very rarely, indeed, work at coal-getting. The writer thinks that the majority of those present who have served their times in collieries will bear him out when he says that it is quite the exception for any hewing to be done by the pupil, except, perhaps, by way of a joke. Viewed, therefore, by results, perhaps the balance seems to be in favour of students not actually working; for it will probably be held that our coal-mine managers have quite as sound a knowledge of the practical side of their work as have our metal-miners,

whilst American mining engineers can at least hold their own with their German fellow-workers. At the same time the writer wishes to avoid expressing anything like a dogmatic opinion on the subject; the advocates of both these modes of learning mining are so evenly balanced, whilst such eminent authorities hold such diametrically opposite views, that it is hard to believe that one view is wholly right and the other wholly wrong. No doubt, much depends upon the individual student himself, his powers of observation, and his capacities for assimilating information; and it may well be that the method most suitable to one man would entirely fail with another. It will probably be admitted all round, that no student would be any the worse for a year or two spent in actual mining work; but the question is rather whether, given the extremely short time that he can, as a rule, devote to learning his profession, he could not employ this time to greater advantage. It is certainly not a question of scientific training plus practical work, versus the same amount of scientific training without practical work, but rather whether this practical work can or cannot with advantage replace a portion of the scientific training. The writer is rather inclined to think that we have never, in this country, given the American system of "Summer Mining Schools" a fair trial. In this system the student spends his long vacation each year in a different mining district. He goes underground every day, and after a few days spent in familiarizing himself with the general character of the mine, he is assigned to each particular portion of it in rotation, and is made to study this exhaustively, care being taken to so parcel out his work that he gets to see every different mining operation that is going on in the mine in question. He has to keep a journal and make full notes of each day's work, an outline scheme being given him that shows him exactly to which points he should direct his attention.

In the best system, the students are accompanied by an instructor, who every night examines and corrects the notes of the previous day's work; these instructors also divide the entire number of students into small squads, and visit each squad several times during the day, so as to see that they do their work properly. One of the most experienced professors of mining in the United States writes to the author on this subject, that the essential conditions of success are:—"Maintaining strict discipline in the class," "dividing the class into squads," and "requiring a definite amount of work each day," and on the important question of safety, he says that: "there has been but one accident, a broken arm, in 20 years."

The high pitch of efficiency to which American mining engineers have indisputably attained, makes the writer think that it might be worth while

to attempt to copy their method of training, introducing such modifications as the conditions of work in this country seem to require. The writer would like to see our mining students at the various mining colleges of the country sent during each long vacation to different mines, being distributed, say, in squads of two or three. If possible, it would no doubt be mutually profitable that the squad mates should be of about the same collegiate standing, but from different colleges. They should be subject to the orders of the mine manager, but should follow a scheme of work previously elaborated by the manager and the mining professor. For their first week they might travel through the workings every day with the submanager (in collieries) or the underground captain (in metal-mines), making sketches of the general nature of the mineral deposit and the mode of working it, which they could amplify in the afternoons by studying the mine-plans. They might then be transferred for a week or a fortnight to winning headways or level ends, where they would learn the methods of working, of drilling holes, firing shots, etc., the proper method of arranging shot-holes, and the effect of various positions of shot-holes and various quantities of explosives. They would then be transferred to other workings, stopes, pillar work, or longwall, as the case might be, and devote their time successively to timbering, underground haulage, shaft work, hoisting, pumping, ventilation, etc. The surface-arrangements, screening or dressing plant would then be exhaustively studied, tracings made of the more important pieces of machinery, and samples collected of all the products for subsequent assay.

The writer is, upon the whole, inclined to believe that three months so spent would be of more value to the student than the same length of time spent in learning to strike a drill or to hew coal. Above all, it must be clearly understood that he holds most emphatically the opinion that neither this scheme, nor any other, will turn out a man competent to be a mine manager when he leaves college ; all that the college can hope to do at the very best is to render him really fit to start fair at the lowest rung of the ladder. This point cannot be too strongly insisted on. All that the most thorough and practical college training can possibly do is to fit him to commence to acquire the technical experience that he will need in his subsequent career, but in doing this, it does what no subsequent experience can wholly replace. In the writer's opinion, one of the capital defects of the law, which prescribes five years underground for a colliery-manager's certificate, is that it does not recognize to what extent suitable preliminary scientific teaching can fit a man for learning.

The writer is not therefore suggesting the above summer school as an

equivalent for an underground apprenticeship, but only as part of a student's college training, as an illustration, so to speak, of his courses of lectures. One of its great advantages would be that the student, thus trained, would necessarily be familiar with the practice in more than one district. It nowadays happens too often that a lad is apprenticed in his own district, serves his time there, and subsequently works out his career there, merely carrying on the traditions, good or bad, of his predecessors, and practically ignorant of how others have solved the problems which he has to face. If for no other reason than for the exchange of ideas between different districts that would thus be brought about, this scheme is surely worth a trial.

There remains to discuss the financial bearings of such a scheme; the writer cannot believe that mine-owners would throw any difficulties in the way of students anxious thus to enlarge their experiences; indeed, if only for the most selfish of ends, mine-owners ought to encourage such a scheme by every means in their power. Additional work would certainly be thrown on the mine-managers for which it is only right that they should receive remuneration. The writer ventures to appeal to mine-managers, both coal and metalliferous throughout the country, and to beg that all willing to receive students during the long vacation, say approximately for the months of July, August and September, will do him the favour to communicate with him, stating the number of students that they would admit into their mines annually and upon what terms. He is most anxious to put the question on a practical commercial basis, and to try the experiment whether the technical education of mining engineers would not be benefited by thus adopting a modification of the the American Summer Mining School.

Another very open question, which, however, most often crops up in the case of coal-mining students, is whether or no they should serve a portion of their underground time before entering the mining college. On the one hand, it is argued that it is better for them to get some idea of what the actual work will be like before definitely commencing their college career, and that they will understand the value of their theoretical work better if they first have some conception of its practical application. On this question, the writer holds pretty decidedly the opposite view, and considers that the student should get his college work done before he commences to do his regular work in the pit. In the first place, he will come to college fresh from school, and therefore better able to acquire his theoretical knowledge of science, than after he has dropped his book work for a couple of years. His practical pit work will do him more good,

he will learn it more thoroughly and appreciate it more critically, if he understands the scientific basis that underlies it. It seems more logical to commence with the theory and to learn its applications afterwards, than to reverse this process, though the writer willingly admits that in exceptional cases the latter course may be the better. By this system, too, the student will come to his pit-work a few years older, when his frame is stronger and he is better able to bear the fatigue that honest work underground necessarily entails. Hard work that might injure a lad at 16 may do him good physically at 19. Finally, should a lad have gone through his college career and then find that he is either physically unfit for pit-work, or that it is entirely distasteful for him to continue in that profession (both very unusual contingencies), his college work will nevertheless not be wasted, because the bulk of what he has been learning will form a sound basis for any branch of technology to which he may wish to devote himself. For all these reasons, which seem to the writer upon the whole to rather outweigh those that can be advanced in favour of sending a lad to the pit first, he holds that it is preferable that the college work should precede that of the colliery.

Another point that requires insisting on, is one already alluded to, namely, the necessity for not training a student up from the beginning as a coal-miner or a metal-miner. The proper course is to begin by teaching him to be a miner, and after he has learnt the groundwork of his profession, to allow him then to specialize. Here again we feel the injurious effect of our ill-advised legislation, which, by placing the two classes of miners under different laws, almost insists that each shall be ignorant of the methods practised by the other. Were it not for the artificial barriers thus erected, we should hardly see Victorian gold-miners advertizing rewards for any one who will devise a new method for ventilating a mine 3,000 feet deep, as though there were no existing methods, and as though this were not an everyday problem for the coal-miner; nor should we, on the other hand, see the coal-miner so much at a loss, as he sometimes is, when he has to drive or sink through some specially hard rock. Each branch of the profession would benefit by a knowledge of the other, and the mine-manager more especially ought to have an all-round knowledge that is not limited by the special conditions under which he may happen to be working. The writer would even like to see, within certain limits, experience in a coal-mine count towards the certificate of the metal-mine captain, and *vice versâ*.

In this country, we strangely enough neglect almost entirely the commercial side of technical education. The writer has seen a graduate from

a British mining college narrowly escape criminal prosecution simply and solely because, holding the position of mine-manager, he was absolutely ignorant of the very rudiments of book-keeping. Mining jurisprudence, the mining laws of our own country, our colonies and the chief foreign countries ought to be studied, a certain amount of commercial law ought to be included, and book-keeping and accountancy ought to form a special branch of mining education, instead of the young mining engineer being left to himself to pick up a half understood smattering of these subjects, or else to learn them in the hard school of experience at his own expense or that of his employers, as the case may be.

It will appear from what he has said that the writer considers our present system of mining education to be in many respects a faulty one, though materials for its improvement are readily available. An effectual improvement can, in his opinion, be effected only by an alteration in the law, and the chief reforms the writer would advocate are the following :—

1. Every manager of a mine, whether coal or metalliferous, should hold a certificate.
2. Certificates should be granted upon examinations controlled by a central board, making the examination identical in conditions and character for the whole of Great Britain (and, if possible, for the colonies also).
3. A minimum of scientific training should be insisted on, and residence in a recognized scientific college should count up to, say, one-half of the apprenticeship required. At the same time a minimum of underground training should be also insisted on, say, 3 years of each for example.
4. Every mine-surveyor should hold a certificate of proficiency.

The writer ventures to think that these suggestions are neither very drastic nor very revolutionary, and is at the same time convinced that very much good would result from their adoption. In conclusion, he can only urge upon all interested in the mining industry of this country that one of our most imperative needs, if our country is to continue to hold her place in the industrial world, is the higher scientific education of the rising generation of miners, and the recognition of the value of such scientific training by the legislature, the mine-owners, and the country at large. We see on every side mine-owners cheerfully spending vast sums in the adoption of modern processes, the erection of the most improved plant, and the acquisition of the most perfect machinery, and it is surely a short sighted policy that would at the same time grudge the necessary expense for the development and improvement of the human machine that is to guide and control all the others.

Mr. A. L. Steavenson asked, as the writer of the paper thought that it would be better to have metalliferous and coal-mining combined, how students living in a coal-mining district were to obtain practical knowledge of metalliferous-mining, and *vice versa?* Prof. Louis stated that in future they were likely to have large colliery concerns, which would require careful administration; but at the present time mining engineers had charge of outputs of 7,000 to 10,000 tons of coal per day, and he doubted whether these figures could be improved upon or increased. The members were told that it was very necessary to have a knowledge of chemistry, in order to study the sometimes complex reactions continually taking place in the mines. Undoubtedly, an engineer would be better for having a knowledge of chemistry; but, so far as collieries were concerned, it would not be necessary to have any great knowledge of it, for they had a means of getting from their analysts weekly records of all that they did, and he thought that his time would be better employed in looking after the affairs of a colliery than in ascertaining in a laboratory how much ash there was in certain coke. Colliery-owners insisted on having a great deal to do with the selection of their agents, and they preferred a man who had seen the work of which he had to take charge, and was thoroughly familiar with it; and if they thought his knowledge had been acquired in a college, they would not so readily accept it. At present, examinations for certificates were conducted by examining boards, which appointed the examiners and fixed the conditions under which candidates should sit. Each board comprised three coal-owners, three mining engineers, and three representatives of the workmen; all parties would persist in expressing their views when they had to decide upon the conditions under which a man was to be examined, and he doubted whether the miners would accept the proposal that a certain period of study at a college should be accepted in substitution for practical mining work.

They were told in the paper a great deal about what foreigners knew, and what we did not know; but the foreigners came over here in swarms, picked up our ideas, and returned home and published them. In a recent issue of a technical journal, there was a drawing of an American coal-washing machine described as something new; but it was merely a combination of two coal-washers—the Robinson and the Ramsay—the inventions of two north-country engineers. British coal, hitherto, did not require washing, but in Germany it was not unusual to spend upwards of £10,000 for one machine, which would only wash 500 or 600 tons a day. He did not in the least wish to deprecate or depreciate the value

of scientific training. He had been for 42 years a member of The North of England Institute of Mining and Mechanical Engineers, and considered that mining institutes were especially adapted for promoting scientific knowledge all over the country.

When he was President of The North of England Institute of Mining and Mechanical Engineers, a few years ago, he recommended that the mining student should leave school at, say, 16 years of age, and spend a couple of years in the pit; and a young man of 16 years could run about the pit more freely than when he got older, and could get into communication with the workmen in a better manner than he did later. Then he might have 2 or 3 years at a mining college, and afterwards take a subordinate position, such as that of a back-overman, before completing his mining training. There was plenty of time between 16 and 25 years of age to serve an apprenticeship, to go to the college, and do practical work; and he agreed with Prof. Louis in regard to that opinion. He did not suppose that he would have another mining pupil, as he had got to an age now when he did not care to run about with them; but, speaking of the young men that he had had, he thought that they had learned more with him than they would have done under the system recommended in this paper.

Mr. M. H. Mills (Mansfield) said that, as a mining pupil who had served his time with the late Mr. T. E. Forster, one of the best-known mining engineers in this district, he, to a certain extent, agreed with Prof. Louis that it had now become necessary that young men should have a more thorough scientific education; but it must not be at the expense of practical knowledge, and he thought that Prof. Louis admitted this. He had found that the young men whom he had employed as managers and under-managers had been deficient in mechanical knowledge, and he thought it desirable that part of the training should consist in going through shops, particularly repairing shops, so that they might have more knowledge of machinery than usually existed at present.

Mr. G. B. Forster (Newcastle-upon-Tyne) said they would all agree with Prof. Louis upon one point—namely, that a great increase of technical knowledge amongst their people was very much desired; but he did not agree with Prof. Louis' statement that many accidents were attributable to a want of knowledge. He knew that it had become the fashion to say that many accidents were due to men's carelessness or ignorance; he did not think that this was the case, and he did not think they should allow such an idea to go forth to the world. Under the 1871 Coal-mines Regu-

lation Act, the examination-boards had power to allow residence or attendance at college to count in lieu of practical experience in a mine. That plan had worked very well, and it was a pity that such a regulation was abolished by the present Act of 1887. He thought that measures should be taken to represent to the Government that the enactment was doing harm to the technical education of the country. He agreed with Prof. Louis and disagreed with Mr. Steavenson with respect to the mixture of college and practical experience. He (Mr. Forster) had often been asked whether a young man should go to college or to the pit first, and he had always said that he should finish his collegiate course before he applied himself to the practical study of his profession, as he had always found that, after once leaving college, young men were averse from resuming their studies.

Mr. Thomas Douglas (Darlington) said that as an old pitman he very largely agreed with the views expressed by Prof. Louis. There were, however, one or two points on which he differed from him and some of the previous speakers. His own impression had always been that it was better, remembering that a young man had the opportunity of attending many classes previous to the time when he entered upon his apprenticeship, that he should first of all be introduced to the physical work of the colliery and travel about in the pit, noting what he had an opportunity of seeing. He thought that was the material advice which he had strongly impressed upon many a young man with whom he had been associated during a long career.

He (Mr. Douglas) went into the mines in 1845, when he was 16 years of age, having previously had the opportunity of instructing himself in several of the subjects mentioned by Prof. Louis, such as chemistry, geology, etc. He was for 2 or 3 years in the mine at that time, and distinctly remembered a letter written to him by Mr. Edward Fenwick Boyd, a mining engineer, now passed away. He wrote to him very feelingly in reference to the subjects which he ought as a young man to study, but the subjects mentioned were so many and so diversified that he found that if he attempted to carry out the programme he would not have any time to give to the practical management of the collieries of which he was in charge.

When he (Mr. Douglas) was an apprentice, collieries were jealously closed to all but those who were engaged at the individual collieries concerned, and colliery-owners would not allow their collieries to be examined by anyone who chose to visit them. He was fortunate himself in having an opportunity under Mr. E. F. Boyd, who was largely interested as

check-viewer at different collieries, of visiting nearly every colliery in the counties of Durham and Northumberland, and elsewhere; and the experience thus gained was to him of immense importance. Nowadays, colliery-owners were always pleased to have their collieries inspected, and this was of enormous advantage to the young mining engineer.

He agreed with Prof. Louis as to the importance of combining scientific and practical training, but he rather thought that the young man should be first engaged for a few years in practical mining, and that afterwards he should study in a mining school. On his return to colliery work, he should have responsibility imposed upon him under proper supervision, so as to enable him to take an interest in the work of the colliery and carry it out as if he were entirely responsible for it.

Mr. Jeremiah Head (London) thought that Prof. Louis deserved the thanks of the members and of the profession for having brought this matter so very clearly before them. He thought that the writer must not be criticized too severely, as though his ideas were of an entirely visionary kind. As he (Mr. Head) read the paper, he thought that the writer intended to call attention to the difficulties attending the attainment of higher education by our mining engineers. He had intended to put these difficulties before them with a view to further discussion and the elimination of as many obstructions as possible; and the questions that he had raised, he thought, applied not only to the mining branch of engineering, but to engineering altogether.

There was no doubt whatever that to a certain extent foreigners had gone ahead of us. Mr. Steavenson, in his pointed way (and there was no one whose observations deserved greater attention as being concentrated common sense than those of Mr. Steavenson), referred to the number of foreigners who came over to Great Britain to see what we were doing; and the inference, although he did not know that Mr. Steavenson intended it, was that we were still recognized as the sole or principal source of information on technical subjects for the whole world. There was no doubt that this was so in the earlier part of this century, and that we had been the great schoolmasters of the whole world in practical engineering. The most important inventions had originated in this country, and we had taught them to other countries; but this state of things had largely passed away, owing to the activity of foreigners in coming here and to other countries to see what was being done; and, improving upon them, they managed to push ahead of us in several directions. He had crossed the Atlantic some 16 times, and he had observed that for every British engineer going there at least 10 Americans came over here. Such a

transfer of knowledge as that must tell in the long run. Consequently on the other side of the Atlantic, American engineers were systematically informed of all that was going on in this country and the Continent of Europe, and it was re-taught to the students in their universities. He thought that, in addition to the very valuable knowledge to be got by young men in practical work and in technical schools, their young engineers ought to travel abroad for a year or two, at least, to see what was being done in other countries, and to free themselves from narrow insular prejudices.

With regard to the order in which an engineering student should learn the lessons to be derived from practical work and scientific study, Prof. Louis had put forward the views which were almost always enunciated by technical professors. They liked to get hold of a young man straight from school before he had lost the habits which had been instilled in him at school, and when he might be expected to make more headway with book-work than if he had been for 3 or 4 years running about mines. The question whether the practical course first and the scientific afterwards, or *vice versa*, should be adopted, depended on the individual youth himself, his physical strength, his pluck, and other things. He had seen excellent results from boys trained in both ways, and he thought that they could hardly lay down any general law as to which should take precedence. He fully sympathized with the professorial view of it; get the boy early if you can, but he was not quite sure that a better man might not be made in the long run if those exceedingly important years of life—16 to 21—were largely employed in getting practical intuitions and leaving the higher theoretical ones to be obtained afterwards.

Mr. J. H. Merivale (Broomhill) wrote that in considering the question of the training of mining engineers we are, of course, hampered at the outset by the Coal-mines Regulation Act, and the regulations arising out of that Act adopted by the various mining examination-boards. This Act was framed for the purpose of enabling working-men to become colliery-managers, an object with which he sympathized. Unfortunately, the Act seeks to effect this by lowering the standard of scientific attainment required, instead of by giving to working-men increased facilities for study, as had been done at Bochum, and other places on the Continent.

In the first place, therefore, he would say to the young man who wished to become a first-class mining engineer, you must put the Act of Parliament aside altogether. By doing so you will, no doubt, increase

the length of your training and put off by some years the day when you will be qualified to sit for your examination ; but, on the other hand, you will have received a thoroughly good training, for which you will be incomparably the better in the end.

In the first place, it is a mistake to specialize early. A good general education, followed by a course of pure science completed at the age of 19, or thereabouts, is the best preliminary training for the mining engineer. It is also equally good for many other professions. So that the young man, who is now old enough to know his mind, and who finds that he does not after all wish to become a mining engineer, but a doctor, or a lawyer, will have received an excellent foundation for these professions. The next 2 years should be spent at a colliery—not in trailing round the pit after the overman, but in actual practical work. He should put in timber, build pack-walls, lay tram-rails, etc., never alone, but in the company of a skilled and careful workman. If he can devote a short time each day to study, so much the better. The third year may be spent abroad at a colliery, say 6 months in France and 6 months in Germany. The pit-shift each morning should be short, so as to leave energy for the study of French and German ; and, if opportunity offers, science and drawing should be maintained.

Returning home, during the fourth and fifth years he should travel the pit in the morning in charge of a small district, go into the office in the afternoons, and attend mining lectures and practical laboratory work on Saturdays.

The student will now be about 24 years of age and a qualified mining engineer.

Mr. W. C. Blackett (Durham) wrote that Prof. Louis' paper was one which should be carefully read and digested by every person about to enter upon the profession of a mining engineer, and by every one interested in the advancement of young men in that profession. While, however, he (Mr. Blackett) recognized the many valuable ideas expounded by Prof. Louis, at the same time he thought that gentleman had adopted a tone of pessimism and disparagement of home qualifications which were as unnecessary for his purpose as they were unfounded in fact. It is not conducive to the pride of association which a young man ought to feel at the outset of and throughout his career among British mining engineers, that he should be assured by one who may have to guide some of his footsteps that scientific mining in this country is behind that of others, or that we are behind the rest of the world in our technical science. Such a statement is very far from being correct, and Prof.

Louis does not venture to bring forward many examples by way of proof, and the one or two suggestions of this nature in the paper are singularly unfortunate. Thus, Prof. Louis ventures to think that the subject of assay of the product of a mine has been neglected, because, forsooth, the development of coking in Westphalia has been accompanied by the recovery of bye-products. Indeed, he goes further and states that the "economies in coke-manufacture" there are "consequent on the utilization of the bye-products." He (Mr. Blackett) had to visit 11 years ago some of these very Westphalian coke-ovens in order to report thereon to the late Sir George Elliot, and he ventured to say that this was hardly the correct way of stating the case. Indeed, it would be rather more correct to call the coke in that instance the bye-product, and the recovery of the oils, etc., the main industry. Suffice it to say, however, that the results of his observation were that the coal and circumstances generally were so different from the majority of those in the North of England that it was worthless to adopt any such similar methods at the collieries concerned. This cry of bye-products is far too often raised by persons who do not stop to think out all the circumstances. Are we to be condemned as having no scientific skill because we do not recover sulphuric acid as a bye-product from the brasses of our coal-seams, or make in every case bricks, etc., from our shales, or building-stones from our posts, or paint from the deposits of our underground streams? If not, then why are we so condemned if we do not choose to invest our capital in a chemical works to recover oils from our coal? The whole thing resolves itself into a question of investment, and it is possible that if colliery-owners exist, who have generous supplies of capital, some of it may be invested in chemical works which may, in the absence of severe competition, pay a reasonable dividend.

But the collieries that most of the members of this Institution will have come across have receptive qualifications in the way of capital which are calculated to swallow up advantageously all the money that a generous ownership is likely to supply, and pay in nineteen cases out of twenty upon such additional outlay a better dividend than that likely to be derived from a similar investment in bye-product plants. Of course there are exceptional coal-seams, and cases where it is an undoubted advantage to recover bye-products, but at present they are few and far between, and a multiplication of them would prove mutually disastrous. In all fairness we should not let Prof. Louis condemn our skill because we do not employ it for what may be fanciful and not sufficiently remunerative ends.

Again, turning to coal-washing, wherein Prof. Louis implies we ought to be ashamed of ourselves, because for excellent results we sometimes avail ourselves of the experience of the foreigner. Here again he is most unfair, because the reason for which we sometimes copy the foreigner —even here we do not by any means always do so—is because we have had to follow him, and it has been necessary for him to clean his dirty coal-seams to compete with ours, which have mostly been clean and good. But because our seams have been better than the foreigner's is no reason why our skill is less, or why we should tamely submit to a charge of a lack of scientific knowledge.

Instead of picking out these fallacious arguments, let Prof. Louis point out to students with all pride how strange it would be, after Great Britain had been freely teaching the whole world for so many years, if some of her pupils did not out of their greater necessities show their aptness and their gratitude by returning to her some of the fruit of the seed she had sown in a soil peculiarly adapted for the production of variations.

Neither should Prof. Louis condemn the present Coal-mines Regulation Act on the score that it insists so definitely on practical work being done by one wishing to obtain a certificate of competency to manage mines. It is easy enough to ensure that a student has got enough training in the sciences of mining by thorough examination, but it is not so easy to discover whether such knowledge can be usefully and practically applied, and the legislature has wisely enacted that a reliable certificate of such employment shall be given, and by this means prevent well read persons who may never have been down a pit in their lives from receiving certificates that they are able to do work which they may never have done at all, or have only done for a term of years which would be too short were it less than five.

A mine manager, too, ought to know something more than the science and art of mining. He ought to be able to feel as the men under him feel in all the various situations that exist. He ought to learn how to sympathize with them, and to adjust his sympathies so as to harmonize with the economical possibilities of his mine. He ought to be able to transport himself mentally into the boots of any single workman before entering actively upon any of those numerous differences of opinion which continually arise in the life of a mine, and it is only by long and intimate practical intercourse that he will be enabled to arrive at such a degree of tact as this, such as will commend itself to his employers and their work-people.

Then Prof. Louis seems to contradict himself to some extent on this very subject, inasmuch as he says that the average age for admission to a college for a period of 3 years should be 17, which would make a student's age 20 when he enters the mine, where he would work for 5 years, and then only reach the age which in an earlier part of his paper Prof. Louis says should be the lowest age at which a young coal-miner should sit for his first-class certificate, namely, 25 years.

With most of Prof. Louis' suggestions other than those which involved an admission of the superiority of any foreigner he cordially agreed, and hoped that some of the more needed improvements and reforms might be carried out.

Mr. F. Coultas (Deepcar) wrote that although he concurred with Prof. Louis on most points, and should be glad to see some of his suggestions put into practice, there were other portions of the paper in which he could not agree with him. He might, however, remark that he admired the ideal picture of the practical man, "receiving his technical education," in the early part of the paper, and further agreed with him that this subject was not yet threshed out, and that reforms in the law were needed. If the law provided more facilities for giving the working miner a technical education, many of the lamentable accidents that were still so common would probably be prevented, the mutual interests of employer and work-people would be more fully regarded, and not a few undesirable prosecutions obviated; while the general trend of increased intelligence would be to minimize the active operation of the law relating to compensation for accidents. In the list of subjects enumerated by Prof. Louis, geometry is very lightly passed over, though plane and solid geometry should form the basis upon which the study of mechanics and its kindred subjects should be built; hence he considered a thorough knowledge of geometry essential, in order to simplify and facilitate subsequent studies. An erroneous rendering of section 23 of the Coal-mines Regulation Act is given by Prof. Louis when he states "that the law ranks idleness in one place before hard study in another," and "discourages scientific knowledge in the colliery-manager." Quite the converse of this is the case; and the clause referred to might rather be considered a safeguard to life and property by resolving that no person shall have the direct control of a vast amount of mining capital, or have placed in his charge the lives of large bodies of workmen, until he has become practically acquainted with the conditions under which they have to work, the dangers to which they are exposed, and acquired a thorough knowledge of where and in what form danger may be anticipated, and

what precautions to take to guard against it. On the other hand, the mining examination-board and the examiners appointed under the Act are expected to satisfy themselves, by a most searching examination, that the practical man has an extensive and accurate knowledge of the laws and sciences relating to mining; hence he failed to see that idleness was encouraged or scientific study discouraged. Prof. Louis further states that in the immediate future vast undertakings can only be made to pay by scientific administration. But he ventured to remark that a practical administration, backed up with all the resources of modern science, was more likely to be profitable than the former. There were innumerable little details and leakages which would escape the observation of the scientific administrator, because they did not find their way into report-books or appear on the cost-sheets as separate items; but they were of paramount importance, and required the most searching observance of the experienced manager to detect them. And detected they must be, if the mine was to be worked with safety and economy. Referring to the technical education of the colliery-manager and mining engineer, there seemed to be a desire to convey the idea that a portion of the time required for practical training could "with advantage" be substituted by college work. With respect to this, he would agree with Prof. Louis in insisting upon a minimum of scientific training at some recognized institution or college; but he would most emphatically object to reducing the length of time to be spent in acquiring practical experience. He thought that the better method would be to increase the term of apprenticeship to 7 years (which was quite little enough), and let technical education and practical training run concurrently. There were many reasons why practical training should not be left until the college course was finished; *e.g.*, a freshman from college would be regarded with opprobrium by the main body of miners, and it is not improbable that to a large extent he would be boycotted by the subordinate officials of the colliery, which would prevent his obtaining thorough practical knowledge; and there were many other reasons, which would readily suggest themselves to members that need not be enumerated here. The members of The Federated Institution of Mining Engineers (perhaps more than any other class) realized how necessary it was that there should be a more universal blending of science with practice, and *vice versa*, among every grade of persons engaged in the mining industry; but there was such a diversity of opinion on the subject of technical education that it seemed difficult to arrive at a satisfactory solution. Considering the extent to which the individual interests of members were involved financially, it

behoved the Council of The Federated Institution of Mining Engineers to select a committee and request them to draft out a satisfactory scheme of progressive technical education, and also to suggest in what points and to what extent the existing laws required modification or amendment. Members would then have something tangible to submit to the Government with the view of obtaining legislation thereon, and its importance could not be too strongly insisted upon.

Dr. C. Le Neve Foster (Llandudno) wrote that he cordially agreed with Prof. Louis' four proposed reforms summed up at the end of his paper, and he considered that our present system of granting the statutory certificates needed improvement.

Mr. Claude B. Palmer (Wardley) wrote, as one who had gone through the German method of training a mining engineer as well as having served his time in England, that he might be allowed to express his opinion of the two methods compared. The idea seemed to prevail that, in Germany, a mining student sacrificed a practical education for a theoretical one, and, having been a student at the Royal Saxon School of Mines at Freiberg, he was in a position to contradict that idea. At Freiberg, on joining the Academy (as it is called), a student started with a practical course at either the metalliferous-mines or, if he chooses, at the coal-mines at Zwickau. This course lasted for 5 months, and the student was under the supervision of the mining professor during the whole time, and also of the manager of the mine. The object of this course was to give the student a rough idea of the working of a mine, to teach him the technical names, and to illustrate the various methods of working ore and coal, so that when he started his lectures he could then understand at once what was being talked about. During the practical course, the professor of mining frequently took the students to different mines and explained practically the working of machinery and pumps, as well as the dressing of ore, and washing and cleaning of coal. Only one lecture was given in a week on any subject, viz., on higher mathematics, and the chief object of this was to enable the student to get into the practice of taking full notes at lectures. When the course was finished there was a vacation of 8 weeks, during which time the student was expected to visit other districts to continue the practical study of mining.

Then the real course of lectures commenced for a student who intended to take his diploma, which was obligatory in case of becoming a mining engineer in Germany. The course was 4 years, but

during that time every facility was given to visit mines and works at any time, as a student had the right to visit any Government mine or work. The course of lectures was very elaborate and complete, combining practical and theoretical knowledge. At Easter vacations, students could accompany the professors on excursions. At the close of his academical studies, the student was examined for his diploma; the examination was partly oral, and was severe. After obtaining a diploma, in order to practice in Germany, the young engineer had then to go through once more a practical course of 1 year, and during this time he had to turn his hand to every class of labour in the mine and work practically himself. He also went through a course of book-keeping, and he was then fully qualified to manage a mine.

Having himself studied for 3 years in Germany, and also served the required 5 years in Great Britain at a colliery, he was decidedly of opinion that a combination of the two methods would be the best training. He would make it obligatory for every candidate for a manager's certificate to study for at least 2 years at a mining college and to pass an examination at the end of his theoretical course, but before going to a college he thought that a short practical course at a mine was desirable, as was done in Germany. The practice of serving an apprenticeship with a mining engineer offered so many advantages that it would not be desirable to discontinue this, as the most important part of mining skill could only be learnt by experience gained by continually being about a colliery, and no part of a student's apprenticeship was wasted time. Undoubtedly the Coal-mines Regulation Act of 1887 had a deterring effect on the scientific training of a mining engineer, and here was where the German method compares favourably with the British. In Germany, every mine manager received a thorough scientific training, whereas in Great Britain many holders of first-class certificates of competency had received a scientific training only just sufficient to pass their examination, and this was often crammed specially for the occasion. He could not agree with Prof. Louis that a more scientific training for working miners would lessen accidents; he found that generally in scientific knowledge the German miner and the under officials—such as deputies—were a long way behind the British miner, although, perhaps, overmen had a better training in Germany—as there were special mining schools for these officials with a similar training to that of mining engineers. Under officials had a great advantage in Great Britain, as they could study scientific subjects at technical classes at any time, whereas in Germany it could only be done as a student.

Mr. W. Galloway (Cardiff) wrote that Prof. Louis had no need to apologize for re-introducing the subject of technical education for miners—rather might it be said that the subject had been far too little discussed, so that his contribution came as a welcome addition to what had gone before. The course of instruction which he sketched out for the working miner had the merit of thoroughness, and if the working miner, and those who were morally responsible for his welfare, could only see the advantages that would accrue from raising the standard of education and with it the standard of intelligence, there would no longer be any necessity to point out over and over again, as had been so frequently done of late, that we as a nation were lacking in technical knowledge of the subjects that mostly concerned our national welfare, as far as mining is concerned. The subordinate officials of a mine must always necessarily be chosen from amongst the most intelligent of the workmen, and those amongst them who possessed exceptional abilities would hew their way upwards through every obstacle. But they would hew their way with all the greater certainty and precision if they approached the task with that intelligence which came with education.

He might give an example of the kind of danger to which lives and property were exposed, and the sometimes unnecessary drain upon capital that may ensue, for want of a very elementary knowledge of principles on the part of mining officials. Complaints had reached him from time to time, and were being disseminated also amongst the directors of a certain colliery company, that the ventilation in one of the seams that was being opened up was deficient, and that it was high time a powerful fan was provided to do the work. The workings were not extensive, the shafts were large, and there were steam-pipes in the upcast-shaft. Feeling confident that there was some obstruction to the free passage of the air, he questioned the manager and overman on the subject, and was told that everything was in perfect order. He then made an examination of all the airways, beginning at the bottom of the upcast-shaft and coming last of all to the bottom of the downcast-shaft—the former being used as the winding-shaft, the latter only as a downcast air-shaft. Arrived at the latter point he heard the roar of wind, and hastily conveyed himself to the spot, to be confronted by a sheet of brattice-cloth drawn tightly across the airway, leaving a small aperture about 2 feet wide by 4 or 5 feet high, open for the passage of the air which was sweeping through it like a hurricane. Need he say that he was struck dumb for a few seconds? But, on recovering the use of his faculties, he ventured to ask: "What is this for, and who put it here?" "I did," replied the overman,

obviously taking credit to himself for such a far-seeing piece of mining engineering, "and its purpose is to increase the quantity of air passing through the workings." "How does it increase the quantity of air?" "Don't you hear it blowing?" the overman asked in answer to my question. "Yes, well?" "Well, if you take away that brattice there is so little air passing in the heading that you cannot hear it." "Did you know of this?" I asked the manager—a man with a first-class certificate obtained by examination. "I did," he replied, endorsing his subordinate's act. The mystery was now solved, the brattice was quickly removed; and for long afterwards the heat of the steam-pipes alone gave a supply of 30,000 cubic feet of air per minute, which was more than enough for the workings in that particular seam after they had been enlarged to ten times the area, and the output had been more than quadrupled. This result was attained by degrees, as required, by enlarging the main airway leading to the points from which the various splits set out. He might add, that this was not the only case by very many which had come under his observation, where an elementary knowledge of scientific principles would have avoided egregious blundering.

Coming now to the training of mining engineers, he was entirely at one with Prof. Louis as to the nature and amount of the education with which they should be equipped. They should know arithmetic thoroughly, and mathematics sufficiently to enable them to understand and appreciate the problems of physics, engineering, and surveying as far as they are carried; physics, chemistry, mechanical engineering, electrical engineering, and engineering drawing to the intermediate stage; geology, principally economic; mineralogy, assaying, surveying, dialling, and levelling thoroughly; and mining in all its branches, including ore-dressing and coal-washing. Add to this one or two modern languages, a commercial training, and practical experience in handling men and materials, and you completed the edifice. Over-education begins when one or other of the necessary branches was carried beyond the point of utility, and this was one of the dangers that would have to be combatted in all training establishments. There was a tendency on the part of teachers to over-estimate the value of a minute acquaintance with the bye-paths of their particular subject, which should be fought against in aiming at producing men with open minds and broad views. There was a similar tendency on the part of capitalists, and some of those who have not had the advantage of an education such as Prof. Louis advocated, to set too much store by the mere hod-carrier as opposed to the architect. To the latter class belong those who clamour for nothing but a practical training; and, judging

by the legislation on the subject that regulates admission to the profession at present, the Government belong to this category, or at any rate did so when the last rules were drawn up. They do these things better on the Continent and in America, as Prof. Louis had pointed out.

The question of practical training did not need very much discussion. It was of the highest degree of importance that an under-official should know how to handle the tools, carry out the work, and advise and take counsel with the workmen in the details of their work, and before he could have acquired this knowledge he must himself have been an expert workman. But there seemed to be as little need for a man whose business was to direct the operations of a mine to have himself taken part in doing the actual manual labour as there was for a captain of a ship to have spent part of his time before the mast, a civil engineer to have laboured with pick, shovel, and wheelbarrow in a railway cutting, a railway-manager to have served as a porter, guard, or engine-driver, or an officer of the army to have acted as a common soldier, before becoming fit for their respective duties. The man who aspired to be a mining engineer should be as eyes, ears, mouthpiece, and hands to the guiding spirit of the concern not at the working-faces only, but everywhere from the faces to the office inclusive. Responsibility should be thrust upon him little by little as he showed himself capable of bearing it, and the greater the responsibility the more would he begin to feel at home in his work, and the sooner would he be able to take the full burden upon his own shoulders.

Loafing about a mine, as Prof. Louis quaintly expressed it, was a very poor way of gaining experience in the details of management, and yet that description of exercise, coupled with the ability to pass a very elementary examination, the subjects of which could be mastered by a species of cramming, constituted the only kind of qualification required at present. Fortunately, for the good of the country we had many men who aspired to better things than the requirements of the Coal-mines Regulation Act, but if there were more encouragement their numbers would undoubtedly increase in proportion. Prof. Louis had pointed out the alteration required in the Act as far as education was concerned, and had entered a protest against the absurdity of classing coal-mining and metal-mining as two different branches of knowledge and legislating for them separately. He agreed with him in both of these points. The sooner some rational change was made the better would it

be for the country at large, and, he might add in conclusion, also for the Government, inasmuch as they were not altogether independent of the general prosperity.

Mr. E. Gündel (Professor of English and Literature at the Royal Saxon School of Mines, Freiberg) wrote that the courses of study at Freiberg consist of four kinds:—(1) Mining engineering, (2) surveying (many students study both together), (3) metallurgy, and (4) metallurgy of iron. All students have to go through a practical course of mining for 5 months before they begin their theoretical studies. These latter last 4 years, during which the students of mining and surveying do practical work at any mine they choose, the students of metallurgy at any smelting-works, and many use their holidays for this purpose. After 2 years study, all students have to pass a preliminary examination, and after 2 more years, a final examination for their diplomas, after which they are recognised by the Government as certificated engineers. In order to get an appointment at the royal mines, or at any of the better managed private mines, mining engineers have to go through another practical course of 1 year, during which they have to study practically every branch of mining. The metallurgists have to go through such a course for 3 months at any smelting-works, while surveyors are only allowed to practice at any mine after having worked practically for 1 year at a mine. Mining engineers and metallurgists often go to small private works (especially in Bohemia, Africa, and America) in order to avoid this practical course and save money, which is never allowed to surveyors. Surveyors have to pass a practical examination after their practical course, but this examination does not exist for either mining or metallurgical engineers.

Mr. G. Blake Walker (Barnsley) wrote that he felt a difficulty in making any comments on Prof. Louis' admirable paper, because he was in entire agreement with the arguments and their conclusions. The difficulty which had first to be surmounted was that of making the importance of technical education in mining more generally recognized. Whenever colliery-managers determined that they would require a certain standard of technical education for all appointments in their gift, there would be an inducement to young men who coveted official positions to qualify themselves. Under the present state of things, appointments seemed to be mainly influenced by other considerations; and, while this was so, youths were not only not effectively encouraged to improve themselves educationally, but many felt that, if they had no advantages of position or influence their chances of promotion were remote. The

Federated Institution of Mining Engineers should, therefore, in his opinion, use its influence to encourage the recognition of the possession of technical education as a qualification for positions of responsibility, though this must, of course, be combined with the other qualities of character and tact, which are essential to the control and management of men. With regard to the question of whether the college course most beneficially precedes or succeeds practical experience in a mine, he must say for himself that it was likely to be more beneficial after a young man had had some actual touch with the practical routine of mining. This was the principle acted upon in Germany, where the first year was devoted to becoming acquainted with manual operations. Many youths were in a sort of mental fog, all the time that they were having their college training, for want of a little practical experience. The summer mining-school scheme was, of course, designed to meet this difficulty, and he had no doubt did so satisfactorily. The question was, could it be realized in this country?

He agreed with Prof. Louis that 25 years of age was quite young enough for a man to have independent charge of a mine, and he thought no harm would be done in enacting that no mine, in which more than 100 men were employed, should be under the management of a man less than 25 years old.

The necessity of better scientific training for the colliery-managers of the future was unquestionable. Indeed, the necessity had become so evident and pressing, that we were bound to see more importance given to collegiate education henceforward.

The Council of The Federated Institution of Mining Engineers ought to urge upon the Home Office the recognition of at least 2 years at a recognized mining school as a qualification for the granting of first-class certificates.

Mr. Robert H. Richards (Professor of Mining Engineering, Massachusetts Institute of Technology, Boston) wrote that he had read with much interest Prof. Louis' sketch of what should be required as preparation for the mining profession, and found it very complete and thorough. He would advocate more mathematics than the author did, because of its educational value. He thought also that the modern engineer should be able to read intelligently books which use the calculus. There are no hard-and-fast rules about taking practice in mines before, during, or after the school-work, and one could point to instances where each of the three methods was successful. As a rule, it would be more practicable to put in practice during vacations, or after the schooling is

over than before it. Vacation work was most admirable, as opening the eyes of the student to the meaning and use of the studies which he pursued during the following term. This might be done either in a summer school or by working in a mine, but the greatest good would not come from working at one thing, and only one, during the whole summer. The most important point of all was the manner in which the instruction was given. For example, the teaching in all the experimental subjects should be aimed to cultivate the scientific habit of mind, so that the pupil could make an observation properly, could record the results of it accurately, could collate and compare it with what was already known judiciously, and could draw his conclusions wisely. There was ample opportunity in the curriculum laid out by Prof. Louis for developing this power, and yet a pupil might go through it and not acquire the development indicated. A pupil who had this power, but had received only a portion of the curriculum, would make a better engineer than the one who had received the whole but had failed to develop this power.

Prof. Louis said he found himself at the outset in this much of a difficulty that, as he had said in the paper itself, it was not possible or desirable to attempt to prescribe limits to genius or to legislate for exceptions. The gentlemen who had done him the honour to speak upon this paper were all men of eminence in their profession, and as such were themselves exceptions, and they had quoted their own experiences as examples, and in doing this they had done the very thing which he had pointed out should not be done. Mr. Douglas, for instance, told them that when he went down the pit at 16 years of age he knew his chemistry and geology then. Surely that was exceptional—

Mr. Douglas : Only to a limited extent.

Prof. Louis said that "only to a limited extent" was, he regretted to say, quite exceptional. Dealing with the various questions that had arisen, and taking Mr. Steavenson's remarks first, he was afraid he agreed with nearly the whole of them, for they were nearly all what he had said, only in very different words. Mr. Steavenson asked, for instance, How coal and metalliferous mining was to be treated on the same basis, and how were they to get their experience ? He had pointed out in the paper how he wanted them to send the students about different mines so that they would acquire experience in the way suggested. He had stated in his paper that "here again we are hampered by the absurd legislation which considers time spent in loafing about a colliery better employed than in studying at a college," but he also went on to say that he did not for a

moment mean to imply that all time spent at a colliery was spent in loafing any more than he meant that all time occupied at a college was profitably employed. What he meant to emphasize was, that present legislation recognized the period spent at a colliery, no matter if that time were spent in idling about, whereas, however hard a young man might choose to work at college, the law made no recognition of the time spent there. He ventured to think that he had not suggested in the paper that a young man should be allowed, as Mr. Steavenson said, to go about the pit without any one in charge; on the contrary, he had said distinctly that during their long vacation they should be subject to the orders of the manager.

He was very much obliged to Mr. Steavenson for his statement as to foreigners coming over here in such numbers, for this was exactly what he was advocating, namely, that students should travel about a good deal and learn all that was to be learned in different districts and different countries, for while foreigners came here to learn what we were doing, we were stopping at home.

Several speakers had referred to the question as to whether the student should go straight from the school to the pit or take the college course first. Personally, he thought the latter method the better one, but there was a good deal to be said on both sides. He had tried in the paper to bring forward debatable points—points which wanted further discussion, and upon which good could be done by threshing them out. He quite agreed that this was one of the open questions on which two views could very easily be held; in special cases one view and in other cases the other would be the right one. He quite agreed with the view that what he had said applied more or less to all branches of engineering, and if an essentially mining student got a little experience in repairing-shops it would be most valuable for him. All this was part of the American system of which he thought so highly.

It was an unpopular attitude, but he could not help maintaining it, that we were distinctly behind other countries in scientific knowledge, although we were first in muscle and manual skill. To take the case of sinking, we were as good as anybody in forging ahead through hard rock, where it was a case of getting down as quickly as possible; but when it came to such difficulties as quicksands and running water, we adopted the Gobert, Kind-Chaudron, Pœtsch, or any of the other half-dozen foreign systems he could name. Did anybody know of a British method?

He (Prof. Louis) thought that the whole discussion had brought out a great deal of valuable comment upon a subject that was really one of

the most vital importance, and he thought that he might perhaps be doing more useful work if he attempted to summarize the discussion rather than reply to it in detail, more especially as there was scarcely a point that had been raised by any one member that had not been efficiently answered by the remarks of others. As was only to be expected, very wide differences of opinion had been manifested on most of the points; they knew well enough what widely divergent views would be put forward as to the best method of developing such an essentially concrete thing as a new coal-seam; it was only to be expected, therefore, that still greater divergencies would appear when it was a question of developing so intangible an object as the intellect, where the difficulty of judging by results was so greatly complicated by collateral considerations. The only point upon which he thought that the consensus of opinion was fairly universal was that the present system in this country does really leave a good deal to be desired, and he thought that an overwhelmingly large majority endorsed the alterations and reforms which he (Prof. Louis) had advocated; some, like Dr. Le Neve Foster, Prof. Galloway and Mr. Blake Walker, appeared to be in complete agreement with the whole of his suggestions, whilst most of the others who had taken part in the discussion agreed with some of them, so he ventured to think that the discussion had brought out strongly the general feeling that the present system needed alteration, or, as Prof. Merivale put it, a man who wished to become a really good mining engineer must disregard the Act. This seemed to be the opinion even of Mr. Blackett, whose refreshing insular optimism the writer admired, although he regretted that he found himself unable to share it. Sometimes an outside view was apt to be the clearest and the least influenced by individual rose-tinted or blue spectacles, and it so happened that such an outside view was here available. A communication had lately reached the writer from the Transvaal to the effect that the Boer Government had instituted an examination for mine managers, and was declining to grant service certificates. This examination included a good deal of pure science as applied to mining, and it was freely stated that the object of this was to prevent British mine managers and mine captains out there from passing this examination, and that as a fact the great majority even of those actually managing mines out there were failing to pass it. He could not vouch for the accuracy of these statements, but the mere fact that it was openly said that an examination in the sciences upon which their work rested would suffice to handicap British as against foreign mine managers showed quite con-

clusively what others think of our method of training. He did not know whether Mr. Blackett would look upon this as a legitimate ground for national pride; his own national pride rested, he ventured to think, upon a more secure foundation than Mr. Blackett's, because while he recognized the excellent work done by British miners and mining engineers, he could not help seeing it was due to the splendid qualities of the men themselves, and was accomplished not because of but in spite of a method of training, which he still held was a most defective one.

He would like, however, to point out that Mr. Steavenson and Mr. Blackett had apparently, and Mr. Coultas had certainly, misunderstood him, and he admitted that the passage (where he had discussed the amount of practical work that was desirable in training) might be open to misconception. He meant here by "practical work" not "practical experience," as Mr. Coultas had interpreted it, but "manual work." With the sole exception of Prof. Merivale, no one who had taken part in the discussion seemed to look upon such manual work as of any value to the mining engineer, and some, like Prof. Galloway, were directly opposed to it; there seemed, therefore, to be a fairly general consensus of opinion that manual work need not form part of the mining engineer's curriculum. He himself had only expressed a hesitating opinion on this point, but he certainly never intended to suggest that practical training, as distinguished from manual training, was not requisite. Indeed, as Mr Blackett and others had pointed out, the scheme of education which the writer advocated allowed full time for acquiring such practical experience during a period of apprenticeship; and, as he himself held, and had tried to show both in this paper and elsewhere,* this apprenticeship is invaluable, and no amount of scientific training can possibly take its place. On this point he is quite at one with Mr. Coultas, their apparent difference being due to Mr. Coultas having misunderstood the writer's meaning.

On the question whether the practical or the theoretical side of the training should take precedence in time, or whether both should run on simultaneously opinions seem to be very divided, each method having its strong advocates. There is no doubt much force in the argument urged by several members, and which was also emphasized in a letter which the writer had received from Prof. R. Beck, of Freiberg, namely, that a lad is likely to get more at home and into closer touch with the workmen, and to pick up their ideas more thoroughly if he goes straight from his school to the mine, instead of passing through the technical college first; many, however, like Mr. G. B. Forster, whose opinion was entitled to the

* *Trans. Fed. Inst.*, vol. xii., page 162.

highest respect, hold that a young man should finish his college course first before going into the pit. The adherents of each method seem to be, however, about equally divided, and the general result of the discussion may be fairly said to be that it does not matter very much in what order a young man takes the various branches of his training as long as he gets them all in, and that it must largely depend upon the idiosyncracies of each pupil as to which course proves the best. Whilst fully admitting that different individuals undoubtedly require different methods of training, the writer may perhaps be pardoned, if, in view of the great diversity of opinions expressed, he adheres to those set out in his paper.

The character of the scientific training recommended by the writer seems to have met with fairly general approval on the whole, though some, like Mr. Steavenson, seem to think that he requires too much chemistry, and others, like Prof. Richards, that he demands too little mathematics. He fully agreed that to fix the exact limits to which each science should be carried was almost an impossibility; all that could be done was to insist upon a minimum, and he would then expect that the student would upon that foundation develop in the direction for which his natural qualifications best fitted him. A mining engineer might with advantage specialize in mathematics, or chemistry, or physics, or geology, or in any of half a hundred other subdivisions of science or technology, and would find his advanced specialized knowledge of value in certain departments, though not at all indispensable in his regular work; all that preliminary training can do is to fit him to be an all-round man, so that he can start with equal readiness in any direction towards which circumstances or inclination may impel him. As long as the distinction between coal and metal miners—this unfortunate subdivision (*unselige zerspaltung*) as Dr. Beck has called it—shall continue to exist, the all-round mining engineer will be hard to find in this country, and this fact has been fully recognized by all who have expressed any opinion on this point.

Of course, a basis of pure science is necessary before applied science can be taught, but in the writer's opinion this latter teaching is also necessary, and this seems to be also the opinion of the majority of those who have joined in the discussion, although Prof. Merivale lays very little stress—too little the writer thinks—upon this teaching. He was very pleased to have Mr. Palmer's opinion on this point, as his experience of Freiberg training would serve to show how carefully these subjects are studied in what is after all one of the first mining colleges of the world; Mr. Palmer, he notes, endorses his own statement as to the manual training insisted on in Germany.

Whilst great differences thus exist upon all points of detail, it clearly results from the discussion as a whole that the present system of training is unsatisfactory, that a much larger amount of scientific teaching than has hitherto been thought adequate is urgently required, and that our present legislation is one of the greatest bars to higher scientific education, and therefore urgently needs reform. The writer cordially welcomes the suggestion that has been made that the Council of The Federated Institution of Mining Engineers should select a committee to investigate the whole subject. Seeing the importance and magnitude of the interests at stake, he feels convinced that the Institution could not possibly engage in any work of greater national utility.

The PRESIDENT moved a vote of thanks to Prof. Louis for his paper, which had led to such an interesting discussion, and it was cordially accorded.

DISCUSSION ON MR. A. R. SAWYER'S PAPER ON "THE SOUTH RAND COAL-FIELD."*

Mr. W. S. GRESLEY (Erie, Pennsylvania, U.S.A.) asked the author upon what grounds he based his belief that the vegetable matter of the coal, to which he referred in the fourth paragraph of his paper, was carried into the basin from the margin of the coal-field; in other words, was drift-coal. Did it appear that anything in the coal itself, apart from the earthy laminæ in it, supported the idea that the vegetation of which it was composed was terrestrial or subaërial in character, and not aquatic? Had Mr. Sawyer viewed this coal as possibly of aquatic origin, *i.e.*, formed of plant-remains which grew under water or in muddy water, or had he merely taken it for granted that the earthy films separating the coaly material, and the absence of under-clay, made it sufficiently evident that the vegetable matter was transported from a distance and deposited as sediment or in fragmentary condition? It seemed to him that the point whether the material grew on the spot or was floated into the "basin" must be settled by a microscopic examination of such plant-structures as the coal might yet contain, and a determination of the way in which the coaly laminæ occurred in relation to each other as well as to the surrounding matrix; for presumably this coal was chiefly built up of bright brittle laminæ not dissimilar from most other coals. The observed paucity of fossil plant-remains in these Coal-measures† naturally

* *Trans. Fed. Inst.*, vol. xiv., page 312. † *Ibid.*, page 318.

suggested that but few originally existed, except those which went to form the beds of coal, and therefore why should not they have been aquatic species and have flourished where their remains now are?

Mr. Walcot Gibson (London) considered that Mr. Sawyer's paper contained many facts of geological interest and commercial importance. The discovery of coal-bearing strata beneath igneous rocks was especially valuable, as it showed that these deposits might be met with beneath the igneous flows which covered wide areas to the east of Boksburg and elsewhere in the Transvaal. It might be questioned whether the lava-flows were contemporaneous with the laying down of the coal-strata. The Transvaal Coal-measures were now considered to be of Middle or Lower Karoo age, while contemporaneous volcanic activity existed in South Africa only in the Upper Karoo or Stormberg period. The apparent interbedding of intrusive lavas was a common feature among the Karoo Beds of South Africa. Mr. W. Forster Brown also gave instances in the Boksburg district of igneous dykes charring the coal in their vicinity.* He (Mr. Gibson) would like to ask Mr. Sawyer whether he thought it possible that the lavas associated with the Black Reef Series, and Gatsrand Beds were of Karoo or post-Karoo age and not contemporaneous as hitherto believed, and if there were lavas of pre-Karoo, Karoo, and post-Karoo age in the Southern Transvaal, whether there were any well-marked petrological characters to distinguish them, as this would be a point of considerable importance in the search for coal beneath igneous flows. The breccia at the base of the coal-strata may be only a local phenomenon, or it might represent a portion of the Dwyka Conglomerate as Mr. Sawyer suggested. The dyke at the Eye of Wonderfontein was apparently the "intrusive syenite and porphyry" of Dr. F. Hatch, and did not therefore belong to the granite (gneissose) series. The map and sections accompanying the paper show that the structure of the auriferous series underlying the South Rand coal-field was complicated, sharp undulations taking the place of the overthrust-faults of the Rand.

Mr. A. R. Sawyer (Johannesburg) wrote that Mr. John Hays Hammond, in an interesting article on the gold-mines of the Witwatersrand, South Africa, discussed the origin of the gold in the Banket formation. It was satisfactory to find that Mr. Hammond and Dr. Becker admitted the solution-theory, at all events in part, which the writer had propounded in 1889 in a paper read before the North

* *Proceedings of the South Wales Institute of Engineers*, 1896, vol. xx., page 134.

Staffordshire Institute of Mining and Mechanical Engineers,* and further exemplified in his paper read before this Institution in 1895.† He was pleased to find that Mr. Hammond agreed with his view as to the angle of dip assumed by the reefs in depth (namely, 30 degrees), at all events to a depth of 2,000 feet. Some years ago, statements were continually made that the reefs flattened in depth, and it was partly with a view to correct any misunderstanding of this statement that he read his paper in 1895,‡ and made the diagram which accompanied it; which Mr. Fred. Jeppe reproduced on his map of the southern gold-fields of the Transvaal in 1896. At that time, the Bezuidenville bore-hole had hardly, if at all, been commenced. By plotting this bore-hole on his diagram, it would be seen that the result obtained as to the position and inclination of the Main Reef Series was foreshadowed in his diagram.

With regard to his paper now under discussion, he would like to add that, acting on his view that the Banket formation on the property of the South Rand Gold Corporation, shown on Plate XV., was the southern outcrop of the Witwatersrand synclinal, and on the results so far obtained the corporation had decided to push forward the system of prospecting laid down, by him, under his supervision, and two large Sullivan drills were already on the spot to bore to depths of 2,000 feet. Should the Main Reef zone be disclosed in the portion marked "Supposed extension of the Banket Formation," on Plate XV., another important gold-mining district might be discovered, possibly equalling that of the Witwatersrand.

Replying to Mr. Gresley, he (Mr. Sawyer) stated that he had not made any microscopic examination of the coal. His view as to the origin of the South African coal-seams generally was based on numerous indications, such as repeated interlamination of coal and shale in the smaller coal-fields, absence of underclay, etc.; and he referred the members to his paper on "Coal-mining in South Africa," read before the North Staffordshire Institute of Mining and Mechanical Engineers in 1889, in which the matter was fully discussed. It was, of course, possible that aquatic species of plants flourished within the deposition-areas, but he believed that the bulk of the coal-seams came from outside.

He was not prepared to reply to Mr. Gibson's question respecting the ages of the various lavas in South Africa. The "amygdaloidal diabase" which he frequently alluded to is a wellknown and thick bed found in

* *Trans.*, 1889, vol. x., page 124.
† *Trans. Fed. Inst.*, 1895, vol. ix., page 360. ‡ *Ibid.*

various parts of the Transvaal, and unmistakable from the numerous amygdaloidal bands which it contains. The amygdules are frequently filled with quartz and agate. These bands have been mistaken for "banket" by inexperienced prospectors in the early days. The sheet lies between the Witwatersrand Beds and the Black Reef Series. The foot-wall of the Black Reef at the Orion mine is, in his (Mr. Sawyer's) opinion, decomposed diabase. The dolomitic limestone formation which overlies the Black Reef Series also contains in places numerous dolerite sheets.

He had just issued a coloured geological map similar to the one accompanying his paper. It differed considerably from that portion of Dr. F. Hatch's geological map recently published. Dr. Hatch stated on his map that he (Mr. Sawyer) gave him the outline of the South Rand coal-field, but Dr. Hatch had unfortunately surrounded the coal-field with diabase on his map.

Mr. Philip Kirkup read the following paper on "The Manufacture of Fire-clay Goods from the Under-clays of Thin Coal-seams":—

THE MANUFACTURE OF FIRE-CLAY GOODS FROM THE UNDER-CLAYS OF THIN COAL-SEAMS.

By PHILIP KIRKUP.

The rapid exhaustion of many of the thicker seams of coal in the Durham district, and the absence of any paper dealing with the subject of the utilization of the under-clays of coal-seams, is the writer's apology for bringing the subject forward in the present paper. The writer intends to describe some of the ways in which the under-clays can be manipulated and prepared for economic purposes, and thus enable many of the thin coal-seams to be profitably worked.

The working of thin coal-seams and the increased cost entailed by having to make height in order to win and work the coal, is of paramount importance to the producer and consumer alike. Increased cost of production means an enhanced selling price or the inevitable closing of the mines through competition with our more fortunate neighbours (who work thicker coal-seams) or foreign rivals. It therefore behoves colliery-owners and managers to look about for any bye-product lending itself to the remunerative working of a thin coal-seam which, by itself, cannot be worked to a profit.

It may be taken for granted that in all coal-fields there are associated with the seams stratified deposits other than coal, which may be worked either along with the coal or independently, and assist in the profitable working of a colliery.

The writer proposes in this paper to deal more particularly with fire-clays and the manufacture of various goods therefrom. The class of goods and the purposes to which they can be applied depend upon the composition of the clay and its freedom from impurities.

Fire-clays.—For the sake of convenience, fire-clays may be divided into two classes, viz.:—(1) Strong and (2) mild or tender.

(1) Strong clays contain a large amount of silica, and when the proportion of alkalies is small, they are, as a rule, very refractory. This class of clay always contains a considerable amount of free silica, which has the effect of reducing the contraction of the articles in the process of

being manufactured. It is therefore especially useful in making certain kinds of goods where excessive contraction in the manufacture affects the value of the finished article. Reference will be made to this matter later on.

(2) Mild or tender clays contain less silica, are more or less rich in alumina, have the property of vitrifying, and the shrinkage in the process of manufacture is greater. The fire-resisting properties are also much lower than in clays containing a larger percentage of silica. The tender clays are, however, none the less valuable for other purposes, as they have the quality, when ground and tempered, known as "consistency" or "body," which is imperatively necessary where more detail and finish are required.

As this class of clay easily vitrifies, it is specially adapted for the making of sanitary goods, and when it burns white is valuable as a facing-brick, making so dense a substance as to be impervious to water or other liquid matter.

Impurities are to be found in all clays. The nearest approach to pure clay (hydrous silicate of alumina), is kaolin or china-clay. Chemically pure kaolin consists of :—

Silica	46·3
Alumina	39·8
Combined water	13·9

Many under-clays are useless for the purpose of making fire-bricks and other refractory goods, from the fact that they contain excessive quantities of lime, magnesia, potash, soda, and peroxide of iron. Of these impurities, potash and soda probably do the greatest harm. Where there is more than 2 per cent. of potash in any under-clay, it is doubtful whether it will make a satisfactory fire-brick.

There are many clays in the Northern coal-field that are of no use for the manufacture of refractory articles, owing to the presence of from 4 to 5 per cent. of potash and soda. These elements act as a flux to the silica, and if such clays are subjected to a temperature of over 2,000° Fahr., they rapidly fuse. Under-clay, which appears to contain a large proportion of mica, easily discerned by its glistening appearance in the clay, is not likely to make a good refractory brick. The reason of this is that mica contains potash which, on being calcined, rapidly fluxes the particles of silica and alumina surrounding each grain.

The percentage of peroxide of iron in combination with other ingredients of the clay, also militates against the value of a fire-clay. Iron,

however, sometimes occurs in clays in an uncombined condition, and when in this state is comparatively harmless, simply acting as a colouring matter and not as a flux. An instance of this may be given in the noted Glenboig fire-clay, which contains an unusually large proportion of peroxide of iron in an uncombined state. This wellknown brick has a peculiar red colour, due to the presence of the iron, but its high refractory character is not thereby impaired.

The relative size of the constituent parts of silica and alumina, and the mechanical condition of the clay when it leaves the grinding-mill, have much to do with the refractory character of the manufactured brick. The larger the grain the less likely is it to fuse when heated, as the ultimate fusion naturally commences outside the grains of mineral. The degree of fineness to which clay is ground and prepared also considerably affects its fire-resisting properties. Clay which is being specially prepared to admit of the contraction and expansion consequent on changes of temperature in coke-ovens and blast-furnaces, must be ground, and passed on to the moulder in a comparatively large and granular state. The same clay if ground fine, as required for building bricks and sanitary goods, would be utterly useless for fire-bricks, which shows the advantage of making goods for refractory purposes from rough clay.

There is no doubt that many of the clays which are now rejected as useless, could be made into fairly good fire-bricks, if they were properly manipulated. These under-clays are probably rejected, not on account of the alkalies which they contain, but from the too near balance of silica with alumina. If to a clay of this class from 7 to 10 per cent. of free silica, in the shape of good sharp river-sand, and a small portion of ground brick were added, the clay having been prepared large and granular, there is no doubt that the mixture on being burnt would make refractory bricks.

The shrinkage or contraction of the clay in manufacture is generally in inverse proportion to the silica found in the clay, and is more or less in direct ratio to its mechanical fineness. Mild clay, which contains less silica and is richer in alumina, has a greater shrinkage in manufacture, and, as a rule, the fire-resisting properties of the bricks are less than in goods made from clays which preponderate in silica.

The writer is indebted to Mr. W. F. Keating Stock, Darlington, for the following analyses of Durham fire-clays and china-clay :—

Table I.

Composition.	Mild Clay.	Strong Clay.	Ganister Clay.	Ganister, after Firing.	China—Clay, Washed.
Silica	52·11	61·66	85·00	97·56	50·50
Alumina	32·01	25·00	7·45	1·43	33·70
Peroxide of iron	3·08	1·16	0·37	0·50	1·80
Lime	0·54	0·09	1·15	0·30	none.
Magnesia	0·72	0·44	0·95	0·03	0·80
Potash	1·36	0·95	0·59	0·09	1·90
Soda	trace.	0·05	trace.	0·09	
Combined water and organic matter	10·18	10·65	4·49	—	11·30

There are two ways of determining the fusibility and refractoriness of fire-clay, which for convenience may be called (1) the theoretical, and (2) the experimental. In the former method, conclusions are drawn from the chemical composition, and in the latter from the changes which the clay undergoes when subjected to intense heat. Chemical analysis shows the refractory nature of a clay by its excess of silica and alumina, and the absence of the fluxing constituents, magnesia, lime, soda, potash, and peroxide of iron. A large experience in the chemistry of clays is, however, necessary before one can determine with any degree of accuracy the character and suitability of a clay, or the mixture of clays, for special purposes. The second or experimental method of finding whether a clay is suited for a specific purpose is probably the readiest for all practical uses. An intelligent study of the chemical analysis, combined with experimental investigation, is, however, the best method to pursue in determining the value of any clay for special or commercial purposes.

As before indicated, under-clays may be manufactured into different articles, and used for a variety of purposes. The clays underlying many of the thin coal-seams in the western part of the county of Durham are remarkably free from impurities, and well adapted for the making of fire-bricks, as well as sanitary goods, etc. For whatever purpose the clay is being sent to bank, the greatest possible care must be used in its selection. This care may be slightly relaxed if only building-bricks are to be made, but for fire-bricks and other purposes hereinafter mentioned, the clay should be carefully sorted, hand-picked, and sent to the surface in large pieces, the greatest pains being taken to reject any clay which contains nodules of ironstone or any indications of impurities or a want of uniformity in its composition. Very serious consequences accrue

from careless filling, and as at least 8 or 10 days must elapse between the time when the clay is sent out of the pit and that when it is discharged at the clay-mill, before the effects of the mischief can be seen in the manufactured goods, it is imperatively necessary for the workmen to exercise the greatest care in the selection of the clay in the mine; and further, when it arrives at bank, the clay should be thoroughly examined before it is tipped at the brick-works. It is only by careful attention that uniform good results can be expected.

As the manipulation of the clay is entirely different, according to the various purposes for which the goods are ultimately used, the writer proposes to describe the manufacture of:—(1) Fire-bricks and other goods made for the purpose of standing more or less high temperatures; (2) the manufacture of white facing-bricks, chimney-tops, and salt-glazed sanitary goods; (3) the manufacture of enamelled bricks, kitchen-sinks, baths, etc.; and (4) the manufacture of gas-retorts.

As mentioned in a former part of this paper, fire-clay may be divided into two classes—strong and mild—and it can be best separated and classified as it arrives at the surface, the strong being tipped into one heap and the mild clay into another. The strong or siliceous kind of clay is specially adapted for the manufacture of fire-bricks and other refractory articles, whilst the milder kind is used for the manufacture of some of the higher-class articles.

Some classes of clay are improved by what is known as "weathering," whilst others do not improve, but deteriorate, by this process. The object of "weathering" is chiefly to improve the "body" or "consistency" of the clay, which is so essentially necessary in the making of the higher-class goods. There is no doubt that strong clays, containing a high percentage of silica and more than a desirable quantity of impurities, especially that of iron pyrites, are improved by exposure to the atmosphere. The air, rain, and frost, set up chemical changes decomposing the sulphide of iron and some of the other ingredients of the clay, making it plastic and more suitable for manipulation, and at the same time increasing its refractory character. It is somewhat peculiar that the clay from the Five-quarter or Bottom Busty seam of West Durham does not improve by weathering. The "consistency" is considerably reduced by exposure to the weather, which can only be accounted for by the fact that this clay is high in alumina and comparatively free from impurities.

With regard to the admixture of free silica in rich clays, which as before indicated, vitrify at a low temperature, there is no doubt that

the refractoriness of the goods can be increased by adding a small percentage of good clean sand—the proportion being based upon the relative quantity of silica and alumina in the initial clay. Where the clay does not contain a larger percentage of alumina than 10, the addition of sand will not, however, increase the refractory character of the bricks, and, therefore, in adding sand to clay care must be taken to (1) consider the chemical analysis, and (2) to carefully note the behaviour of the brick under a continuous high temperature.

The writer has already pointed out the chief points in the consideration of the chemical analysis. With regard to the second point, he would particularly draw attention to the difference between testing the refractory character of a brick in a kiln and that of testing the same in an iron or steel furnace. The necessity therefore of testing refractory goods in a continuous high temperature for a more or less prolonged period, is imperative, before it can be definitely stated that the clay is fire-resisting and suitable for furnace purposes.

Manufacture of Fire-bricks, etc.—The clay having been carefully selected, and coal-pipes, nodules of iron and other rubbish picked out, it is tipped to the mill-house, where it is ground and passed through riddles of varying sizes of mesh to suit the special purposes for which the goods are ultimately required.

A mill for an output of 10,000 bricks per day consists of a cast-iron foundation plate 9 feet in diameter by 3 inches thick, with centre grates. The two rollers, of a weight of 6 tons each, are $5\frac{3}{4}$ feet in diameter by 14 inches wide, and are made of hard freestone encircled by cast-iron hoops, $3\frac{1}{2}$ inches thick. The clay in being crushed is conveyed by scrapers which follow the rollers, on to the centre grates, falling into a hopper or cavity below the floor-level. From this hopper, the ground clay is elevated by travelling-buckets to the top of the mill-house, and from thence discharged into riddles 6 feet long by 20 inches in diameter. The mesh through which the finished clay passes contains from 4 to 8 apertures per inch, according to the fineness required for the different classes of goods. The rougher clay which has not passed through the riddles, falls back to the rollers and there joins fresh clay as it is being fed into the mill.

The fine clay after having passed through the riddles, is conveyed by spouts to a pug-mill—a cylindrical-shaped machine with a vertical shaft, to which are fixed knives placed at such an angle as to thrust the clay out at the bottom of the machine. Sufficient water is added to the dry clay, so that the mill thoroughly mixes the clay to a proper consistency and enables the same to be moulded by hand.

The engine to drive this machinery should have a cylinder not less than 18 inches in diameter by 30 inches stroke, and fitted with a large fly-wheel. The steam should have a pressure of 45 pounds per square inch, and the engine should run at a speed of 40 revolutions per minute. At this speed of engine, the grinding mill is geared, so that the rollers revolve at the rate of 8 revolutions per minute. It is needless to say that the whole of the machinery should be set on good foundations, and be made strong enough to withstand the exceedingly heavy work which it is called upon to perform.

Much has been said and written about the advantage to be gained by moulding fire-bricks by machinery, and there is no question that there would be a considerable saving in the cost of making, but there is the accompanying drawback that machine-made bricks will not stand the work so well as those made by hand. The reason to be assigned for the failure of machine-made fire-bricks is probably the much denser condition of the bricks, consequent upon the pressure exerted in the making of them, as compared with those made by hand, where no pressure is applied. It is probable that if some material, which would maintain the porosity of the brick, could be introduced into the clay as it is being ground, the difficulty would in some measure be obviated.

The bricks are moulded by hand into shapes of various sizes, according to the requirements of the trade, it being borne in mind that different classes of clay and different degrees of fineness, as mentioned in a former part of this paper, affect the relative size of the bricks when moulded to their size when burnt.

The figures contained in Table II. indicate the amount of con-

TABLE II.

Description of Clay.	Composition.		Degree of Fineness, Apertures per Square Inch of Riddle.	Contraction between Size when Moulded and when Burnt, per Foot.
	Silica.	Alumina.		
	Per Cent.	Per Cent.		Inches.
Mild ...	52	32	4	0·527
,, ...	,,	,,	6	0·573
,, ..	,,	,,	12	0·837
,, ...	,,	,,	16	0·925
Strong .	62	25	4	0·275
,, .	,,	,,	6	0·454
,, ...	,,	,,	12	0·605
,, ...	,,	,,	16	0·734
Very strong	85	8	4	0·063
,,	,,	,,	6	0·324
,,	,,	,,	12	0·459
,,	,,	,,	16	0·486

traction between tender and strong clays, and also the variation due to the size of mesh used in preparing the clay.

Drying-flats.—Immediately the bricks are moulded, they are placed upon a drying-flat and allowed to stand on edge for periods varying from 24 to 48 hours, the length of time varying according to the temperature of the drying-flat, and the size and character of the material.

The drying-flat may be heated in three or four different ways, viz. :— by special fires, by steam, by heat from the kilns, or by hot air. In the first three methods mentioned, the channels and the floor must be specially arranged to suit the particular method adopted. Probably the simplest is by special fires situated at the end of the drying-flat, the flues being arranged to join a chimney near the opposite end. For fire-bricks, the best floor is one laid of quarls 24 by 24 by 3 inches thick. An excellent floor, suitable for facing-bricks and better class building-material, can be made by using quarls surmounted by a layer of cement which should not exceed $2\frac{1}{2}$ inches thick. A floor so laid is smooth and level, and ensures the bricks being dried without having their shapes altered, but as the thickness between the heating-flues and the surface of the flat is greater, a larger consumption of fuel is necessary.

Exhaust steam is an excellent way of heating drying-flats. The floor, however, must be laid so as to conduct the heat through the flat as quickly as possible, so that it may not impart the moisture in the vapour to the bricks. The waste-gases from the kilns are sometimes used, either partially or entirely, to heat drying-flats. When this is done as an adjunct to a more permanent method, it is to be commended, but where a flat is entirely dependent upon heat from the kilns, which naturally varies according to the number of kilns at work, and the relative position of the same with the drying-flat, the practice cannot be advocated. In any case, a very good arrangement is to flank the flat with a stack of kilns, so that the waste heat radiating from the kiln-walls and flues will go towards helping the temperature. Cast-iron flat-sheets (where the heat is derived from steam) are sometimes used for the floor, but the method is not to be recommended for this class of work. An excellent method for assisting the drying, which can be applied in any of the ways before mentioned, is to heat the air as it passes into the drying-flat. This may be very easily done by means of a fan or Root blower driving the air through a passage on the top of the kilns, or by some other or special arrangement for heating the air.

A separate drying-flat is required for the making of lumps and quarls, and for this purpose a cement-floor is the best, with the flues running underneath in the same manner as in the brick-flat. For the purpose of drying the lumps, a much lower temperature than in the brick-flat is necessary, as too much heat will break the quarls in the drying process. With a smooth floor, the quarls can be made on the floor itself, and allowed to remain in that position until quite dry and ready for the kiln.

Kilns.—There are many kilns used for the burning of fire-bricks, all of which are said to be more or less satisfactory. The writer, however, will confine his remarks to the ordinary oblong or Newcastle kiln of a size of 15 feet by 10 feet, which at the present time is almost in exclusive use in this district for the burning of fire-clay bricks and lumps, and which, with special furnaces, he has found to be very economical.

The ordinary arrangement of fires to an oblong kiln of the above size is to have one in the doorway and another on each side of it. The fire-bars are made 2½ feet long, and the fire from the furnaces extends up to the front tier of bricks. This renders it necessary to leave always a considerable space between the first tier of bricks in the kiln and the front wall, which reduces the capacity of the kiln considerably. The object of this arrangement is to give space for the fire which is in the kiln itself, and extends right across the front of the same. The fires are fed with cold air direct from the outside which, as will be readily seen, detrimentally affects the temperature of the furnaces and the goods which are being burnt.

With regard to the application of the special furnaces, above referred to (Figs. 1, 2, and 3, Plate I.), it will be observed that the fires are placed on both sides of the door *A*, the central fire in the door-way being dispensed with, and instead of the cold air being allowed to pass into each furnace direct from the outside, it is conveyed along a channel *B* on either side of the kiln for a distance of about 6 feet, returning along a similar passage *C* on a higher level and discharging into a hot-air chamber *D* immediately over the furnace-fire. Air is also admitted on the opposite side of the furnace at an aperture *E* in the doorway, and is conveyed by a channel in the pillaring into the air-chamber *D* on the top of the furnace in a similar manner. The air in the chamber *D*, being in close contact with the fire, is further heated and allowed to discharge by a number of small portholes *F*, and to mix with the gases from the fire so as to support and ultimately complete the combustion of

the fuel. To ensure a regular supply of coal, and to prevent the cold air from passing direct on to the fire, a scuttle *G* is fixed to the furnace-front. It is also desirable to use revolving bars with cogs or teeth, which will be found advantageous for cutting the clinkers and in cleaning out the fires.

It is important to bear in mind, as will be seen from the temperature and the time of burning, as shown in Table III., that the bricks which are being made at the works, at which the record was taken, are of a specially hard kind, a large number going for shipment and for the kilns of cement-works. Considerable quantities of fire-bricks and lumps are also made for coke-ovens, and as such have to be burnt very thoroughly. At a number of works in the Durham and other districts, 6 days' steaming and burning is considered sufficient for fire-bricks. In making a comparison, therefore, of the fuel consumed by any particular arrangement or system of burning the time that the kiln is under fire must be taken into consideration, as also the hardness and the number of soft bricks which are to be reburnt.

The improved furnaces (protected by patent) have been in use at fire-brick works for over 3 years, and the following tabulated record of the burning of one of the kilns may be taken as a fair sample of the work done by them.

It will be seen from Table III. that the improved furnaces consumed in the burning of one kiln of hard-burnt fire-bricks, 13·23 cwts. of coal per 1,000, or 4·20 cwts. per ton of bricks. With the old arrangement, the consumption of fuel was 22½ cwts. of coal per 1,000, or 7·15 cwts. of coal per ton of bricks. In each case, the coal used is of an inferior description, composed for the most part of hitch and outburst coal.

Another advantage gained by the adoption of the new furnace is that the capacity of the kiln is increased, by an extra tier of 750 bricks being placed in the front at each burning. Only 7,850 bricks could be got into the kilns fitted with the old furnaces, whilst 8,600 is the ordinary number burnt with the improved furnaces.

Manufacture of White Facing-bricks, Chimney-tops, and Salt-glazed Sanitary Goods.—For the making of these goods, a mild clay is preferred, which should be ground and put through riddles having a mesh of 12 to 16 wires per inch. The fine clay is passed on to the mixing-pan, which is similar in many respects to an ordinary mortar-mill. Sufficient water is added to the ground clay to knead it into the proper

TABLE III.—RECORD OF BURNING OF NO. 14 KILN, FITTED WITH IMPROVED FURNACES AT BRICK-WORKS, JANUARY, 1898.

Day of Month.	Time of Observation.	State of Weather.	Goods put in.				Aperture.		Quantity of Air Admitted to each Furnace per Minute.		Condition of Kiln.	Temperature.
			Bricks.		Weight.		Side Channels.	Door Channels.	Side Channels.	Door Channels.		
			No.	Size.								
1897				Inches.	Tons.	Cwts.			Cubic Feet.	Cubic Feet.		Degs. Fahr.
Dec. 28	6 p.m.	Fair	4,200	2½	13	2	Open	Open ...	25	20	Steaming	—
			2,000	3	7	10						
			2,400	Side wedges	6	9						
,, 29	6 a.m.	Wet	—	—		—	,,	,,	90	24	,,	—
,, 29	6 p.m.	,, ...		—			,,	,,			,,	—
,, 30	6 a.m.	Wind and wet	—	—	—		,,	,,	112	56	,,	—
,, 30	6 p.m.	Fair	—	—		—	,,	,,			,,	—
,, 31	6 a.m.	Wind and fair	—	-		—	,,	,,			,,	—
,, 31	6 p.m.	,, ,,	-	—		—	Shut	Half open		32	Reddening	900
1898									Air passing through fire-bars	Air passing through fire-bars		
Jan. 1	6 a.m.	Fair	—	—		—	,,	Shut			Red ...	—
,, 1	6 p.m.	,, ...		—			,,	,,			,, ..	1,000
,, 2	6 a.m.	,, ...	—	—	—	—	Open	Open	144	121	Rising heat	—
,, 2	6 p.m.	,, ...					,,	,,			,,	1,400
,, 3	6 a.m.	Wet					,,	,,	129	99	,,	—
,, 3	6 p.m.	,, ...	—	—	—	—	,,	,,			Full fire ...	2,000
,, 4	6 a.m.	Fair	-				,,	,,	154	119	,,	2,400
,, 4	6 p.m.	,, ...	—	—	—	—	,,	,,			,,	2,800
,, 5	6 a.m.	Damp			—		,,	,	135	106	,,	3,000
,, 5	6 p.m.	Wet				—	Shut	Shut			,,	3,000

NOTE.—The kiln was fired with 5 tons 13¾ cwts. of inferior small coal, at the rate of 13·23 cwts. per 1,000 fire-bricks, or 1·29 cwts. per ton of goods burned. The kiln was unloaded on January 10th, 1898, and found to contain hard burnt bricks throughout.

consistency. As facing-bricks are generally made by machinery, the clay should be prepared much stiffer than if the bricks are to be moulded by hand. When, however, they are moulded by hand, the bricks are allowed to stand on the flat a few hours, before being put through the machine-press, and placed on the flat to dry.

Chimney-tops, syphons, sink-gulleys, etc., are all cast in plaster-of-paris moulds, and are allowed to dry very slowly. A moulding-loft erected over one of the drying-sheds is a very suitable place for making and preparing these goods for the kiln, as the heat from the drying-flat warms the upper storey of the building sufficiently to dry the various articles.

Sink-gulleys and other sanitary articles are glazed brown by means of salt. Chimney-tops should not be glazed, as the action of the heat of the chimney and the varying temperature of the atmosphere has a tendency to make them crack and split in pieces, and therefore renders them very unserviceable.

Sanitary pipes are made by machinery, the clay being ground and passed through a 12 to 16 wires-per-inch riddle, and then discharged into a mixing-pan and properly kneaded. A mixing-pan, 9 feet in diameter, driven by an engine with a cylinder 16 inches in diameter by 30 inches stroke, and a steam-pressure of 80 pounds per square inch, is capable of turning out per day any one of the following quantities :—

4,000	feet of	pipes,	2	inches in	diameter.
2,500	,,	,,	4	,,	,,
1,600	,,	,,	6	,,	,,
1,400	,,	,,	9	,,	,,
1,000	,,	,,	12	,,	,,

The clay, after being panned, is passed on to a pipe-machine, which, for any of the quantities mentioned above, should be of the following dimensions :—The steam-cylinder (36 inches in diameter, with a steam-pressure of 80 pounds per square inch) of the pipe-machine is set vertically over a clay cylinder or barrel 18 inches in diameter, and is so arranged that dies can be put on for any required size of pipes. The pressure exerted by the piston on the ram of the pipe-machine is about 25 tons.

The pipes on being moulded are carried off on cradles, and put down on their spigot-ends on a drying-flat, with a perfectly level floor, which should be heated by ranges of steam-pipes fixed about 7 feet from the floor-level. No floor heat is required, the only heat being derived from the exhaust steam from the engine passing through the pipes. When

the machines are standing, a certain quantity of high-pressure steam direct from the boiler may be allowed to pass through the pipes. The sanitary pipes, immediately they are placed on the flat, are taken in hand by "pipe-dressers," who first score the inside of the faucet and dress the end neatly by means of ordinary table knives. Having done this, a wooden drum is introduced, and the pipe is turned end for end. The pipe is then cut to the proper length, which for a finished 2 feet pipe is 2 feet 2 inches long, and dressed in a similar way to the opposite end. Pipes of a greater diameter than 12 inches are turned by means of a winch or other mechanical contrivance.

When the pipes are sufficiently dry, which occupies some 4 or 5 days, they are then ready for the kiln. They should be carefully conveyed, when ready for burning, on trams, fitted with indiarubber tyres, to the kilns. The pipes are set on end, 3 or 4 tiers high, and the loading is completed with sink-gulleys, syphons, and other goods. These latter articles are generally placed on the inside pillars of the furnaces which supply the heat to the kiln.

With regard to a suitable kiln for pipes, there is nothing to excel a round dome-shaped one, as shown in Figs. 4 and 5 (Plate I.). This kiln is fitted with the special hot-air furnace, as before mentioned, and for a diameter of 21 feet has 6 furnaces. The fumes from the furnaces traverse the kiln, and are ultimately discharged into the flues at the bottom of the kiln, and to a chimney-stack of sufficient size and height to ensure a good draught being maintained. The firing of these kilns containing sanitary goods requires very careful management. As a rule, 60 hours are required for steaming, after which the temperature is gradually increased until it is not less than 3,000° Fahr., which temperature is arrived at on the fifth or sixth day, after the furnaces are lighted.

Finally, after the pipes, etc., have been sufficiently burnt, the operation of glazing the contents of the kiln is next proceeded with. This is done by about 4 cwts. of common salt being introduced by means of special stoke-holes into the furnaces, in three successive stages, at intervals of 45 minutes between each charge. While the kiln is being salted, the dampers are lowered, so as to make the fumes hang in the kiln, in order to get the greatest benefit from the gases given off by the volatilization and decomposition of the salt in the furnaces and kiln. The action of the salt in the process of glazing is as follows:—At the high temperature employed, the silica of the clay takes the soda of the salt, and forms silicate of soda, which constitutes the glaze. The

chlorine being burnt out seizes upon the hydrogen of the water-vapour, which is always present in the atmosphere of the kiln, however hot, and forms hydrochloric acid gas, which escapes into the air with the gases of the kiln.

Manufacture of Enamelled Bricks, Kitchen-sinks, etc.—Large sums of money have been spent in making experiments in this line of work, chiefly from the fact that one formula will not suit clays of different analyses. This is due as a rule to the difference in contraction between one kind of clay and another, even from the same seam and neighbourhood, and separated only by a very limited distance. If it be imperative that a careful selection of the clay be made for fire-bricks, it is much more so for the making of enamelled goods. The best clay is that which, having sufficient body, gives the least amount of expansion and contraction in the burning.

As before mentioned, strong clays containing free silica and a minimum of alumina contract the least. This class of clay is, however, not so easily manipulated as the milder kind, and therefore the clay which has an average quantity of silica and alumina, properly prepared, is perhaps the most suitable. To prevent an excessive amount of contraction, from 10 to 15 per cent. of ground brick may, with advantage, be added to the clay whilst it is being ground.

The clay is prepared and the bricks are moulded in the same way as the facing-bricks before mentioned. If, by the nature of the clay the contraction is limited, the glazes may be introduced on to the bricks in a green or white dry state, but this is seldom done, as on account of the contraction in burning, there is always a large proportion of "wasters." The best plan, therefore, is to "biscuit" the bricks, which simply means putting them in an ordinary kiln and burning them slightly. The bricks are then taken out, brushed, and dipped.

Each glazed-brick maker has his own particular methods of dipping, but generally this is done with three mixtures. First, fire-clay slip, which is composed of fine fire-clay and water made to the consistency of pea-soup. The second, called the body, is usually made up of a mixture that will not fuse at a lower temperature than that of the brick itself. The object of the body is to coat the brick with a white layer of sufficient thickness, so as to prevent the colour of the brick from being transmitted to the glazed surface: and the constituents forming the body should be infusible at kiln heat. The third or final dip is the glaze, made of a mixture which fuses at varying temperatures, according to the ingredients

used in making up the glaze. A hard glaze is necessary for bricks, which means that the coating of glaze material must be subjected to a high temperature, in order to make it run smooth. For sinks and baths a much softer glaze is required, on account of the larger size of the goods, and of their tendency to warp and twist, when subjected to great heat. Another reason is that baths and kitchen-sinks are used for inside work, and are not subjected to the varying state of the atmosphere, as in bricks which are used for the most part in exposed situations.

With respect to the burning of glazed goods, the greatest possible care is necessary. The bricks and sinks having been biscuited and dipped, are placed in kilns suitable for the purpose. The bricks are most economically burnt in round down-draught kilns of a capacity of from 12,000 to 18,000. They are arranged in tiers with the glazed surface of the bricks facing each other, and the whole is covered over with quarls in such a manner as to effectually prevent the fire from coming into direct contact with the glazed surface. Sinks and baths are burnt in what is known as muffle-kilns, usually of a square or oblong shape similar to an ordinary Newcastle kiln, the only difference being that there is an inner concentric arch for the purpose of preventing the furnace-fires from impinging against the goods, which would have the effect of discolouring them and affecting their value in the market.

Gas-retorts.—As gas-retorts have to withstand varying degrees of temperature and sudden changes from heat to cold, it is important that the material be of a character that will allow of rapid contraction. With this in view, the clay, after being ground, should be passed through riddles of large mesh, and it may be necessary to add to the clay some other material to increase the porosity of the mixture. The clay in the making of retorts is therefore passed on to the mixing-pan in a rough granular condition. The same mixing-pan can be used as before described under the head of sanitary goods.

The consistency or stiffness of the clay depends upon whether the retorts are to be built up by hand or made by machinery. Machine-made retorts are obviously much more uniform in their composition than those made by hand, from the fact that the retort, being made within the short space of a few minutes, its contraction in the drying process is uniform throughout.

The retort-machine at an ordinary works has a cylinder 60 inches in diameter by 8 feet stroke, a steam pressure of 60 lbs. per square inch, and is set vertically over a clay-cylinder 30 inches in diameter, which

gives an impact to the ram in the latter of about 70 tons. The bottom part of the clay-cylinder is shaped to receive dies for making round, oval, or D-shaped retorts, and the machine is arranged so as to make lengths of 11 feet or less as required. The retorts, varying in weight from 15 to 20 cwts., are discharged through the dies on to an automatic table, which partially supports the retort while it is being moulded by the machine. The retort is thus lowered down until it is made of the necessary length. The huge tube of fire-clay is then conveyed on rails to a 5 tons travelling-crane, and deposited upon the floor of the drying-shed. It is then hand-dressed, bolt-holes are made, and the whole is slowly dried, a process which occupies from 14 to 21 days. When the retorts are ready to be burnt, travelling-cranes convey them to specially constructed kilns, of an area of 26 feet by 10 feet and 15 feet high. Great care must be exercised in the burning of the retorts, and ample time allowed for the cooling down of the kiln. The finished retorts are conveyed and deposited in waggons for transit, in the same manner as they are put into the kiln.

Remarks.—Having generally described the manufacture of various articles made from fire-clay, the writer now proposes to offer a few remarks on the expediency of erecting brick-works or other works for the making of fire-clay goods at any particular colliery.

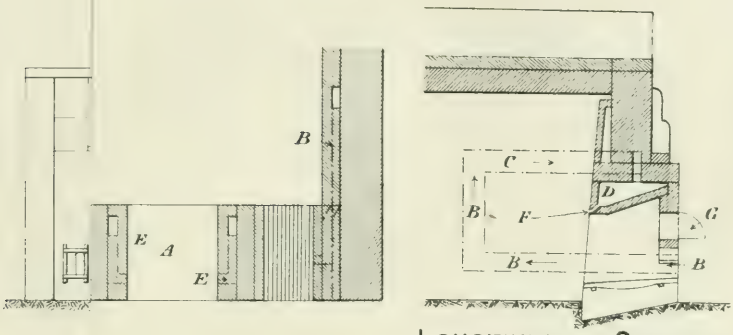
The chief points to determine, when considering the question of utilizing any under-clay, is its suitability for being manipulated and worked up into something of practical utility, for which there is likely to be a fairly constant demand. It is obvious that, in this as in every other business, the demand must regulate the supply, and therefore before spending a large capital in works, the greatest care must be exercised in deciding two questions :—(1) The resources of the mine for supplying the raw material, and (2) the probable demand for the manufactured goods.

The cost of any works for a given output necessarily depends upon the character of the site, and the facilities for procuring the necessary building-material. The position should be as near as practicable to the pit, so that the clay can be tipped direct from the tubs to the mill-house, or into separate heaps contiguous to the works. If this can be arranged, combined with sufficient space for kilns, drying-sheds and ground to stock the finished goods, it will materially assist the economical working of the concern.

The facilities for loading, and the transit of the fire-clay goods, are also matters that must be considered, as it is imperative for successful working that the goods should be easily loaded into railway-waggons direct

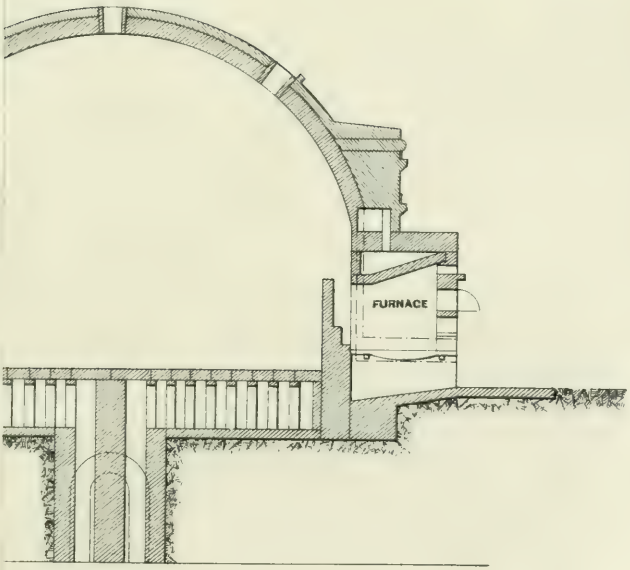
...e Underclays of Thin Coal-seams."

Fig. 3.



Longitudinal Section.

Fig. 5.



Section.

To illustrate Mr. Philip Kirkup's Paper on "The Manufacture of Fireclay Goods from the Underclays of Thin Coal-seams."

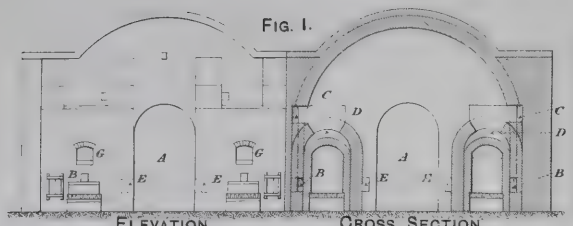


Fig. 1.

Elevation. Cross Section.

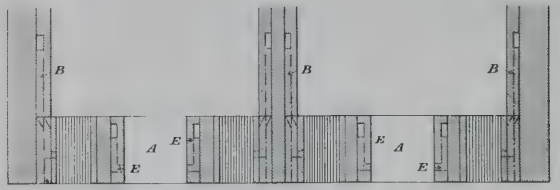


Fig. 2.

Plan.

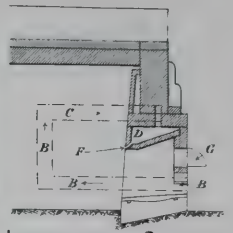


Fig. 3.

Longitudinal Section.

Scale, 8 Feet to an Inch.

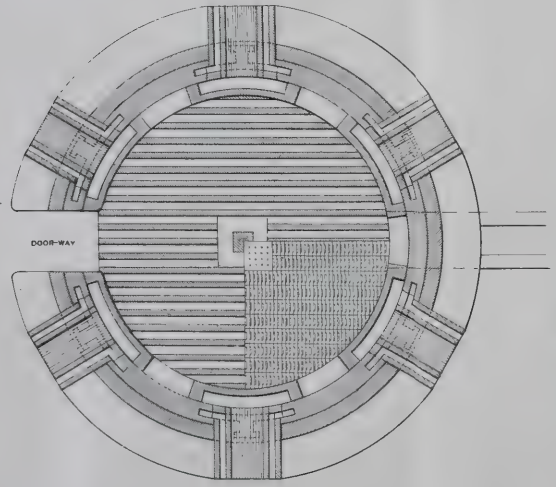


Fig. 4

Plan.

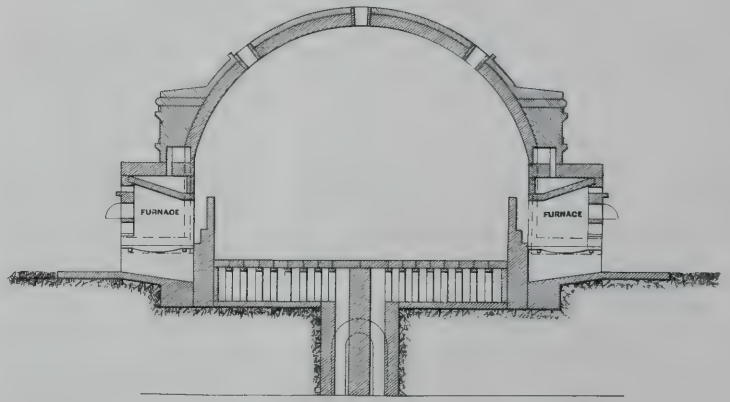


Fig. 5.

Section.

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from the kilns or from stock. These are the chief questions that will require consideration: but, as the conditions are necessarily different at each colliery, the best plan will be to consult an expert engineer, competent to advise upon the whole matter, before laying down capital in works of this description.

The most important point, which more particularly affects colliery owners, is to find an outlet for the under-clay which has necessarily to be dealt with in the working of thin coal-seams. If, therefore, capital is to be sunk in brick-works or other works for the manufacture of goods made from the under-clays, the owner should be content with a small return on the capital invested, relying more upon the saving that will be effected in the cheaper working of the coal of the thin seams of his royalty.

Table IV. shows the saving that is effected on the coal by working the clay out of the narrow working-places as an economic product.

TABLE IV.—COMPARATIVE STATEMENT SHOWING THE COST OF WORKING AN 18 INCHES COAL-SEAM BY THE SINGLE-STALL SYSTEM:—(1) WHEN THE PRODUCT OF BOTTOM-CUTTING IS DEALT WITH AS RUBBISH IN THE PIT, AND (2) WHEN THE PRODUCT OF BOTTOM-CUTTING IS SENT TO BANK IN THE PROPORTION OF 1 OF FIRE-CLAY TO 5 OF COAL.

Labour.	Output per Pay of 10 Days. 1,000 Tons of Coal and no Clay, when Product of Bottom-cutting is Dealt with as Rubbish.					Output per Pay of 10 Days. 1,000 Tons of Coal and 200 Tons of Clay, when Product of Bottom-cutting is Sent to Bank in the Proportion of 1 of Clay to 5 of Coal.				
	Amount.			Cost per Ton of Coal.		Amount.			Cost per Ton of Coal.	
	£	s.	d.	s.	d.	£	s.	d.	s.	d.
Hewing, including making height of 42 inches ..	142	14	2	2	10·25	132	14	2	2	7·85
Putting and datal work...	46	15	0	0	11·22	37	7	6	0	8·97
Bargain and shift-work...	23	19	2	0	5·75	23	19	2	0	5·75
Total underground cost	213	8	4	4	3·22	194	0	10	3	10·57

The 200 tons of clay referred to in Table IV. is delivered at the brick-works at a cost for labour of 2s. 2¼d. per ton.

The writer has not described the manufacture of ganister bricks, as ganister beds are seldom found underlying or associated with seams of coal, except under special local circumstances.

Mr. A. L. STEAVENSON (Durham) suggested the desirability of including in the paper some particulars as to the manufacture of ganister bricks. Ganister was very useful for making into bricks, although it

would not stand where it came into contact with iron in blast-furnaces. About the year 1858, he saw these bricks made in Sheffield by Mr. Young, who had brought the system from Dinas, in South Wales. It was ascertained that the silica was made to take the form of a brick by simple admixture of lime in the shape of milk of lime. Mr. Kirkup stated that ganister contained about 85 per cent. of silica, but this was evidently not a good sample, as he (Mr. Steavenson) had samples with 95 to 96 per cent. The ganister-stone he referred to was found in the Lower Carboniferous measures of Weardale, and called "hazel," which was simply ganister. It was worked sometimes under the Great Limestone, and was made into half-ganister and half-fireclay bricks.

Mr. J. R. Gilchrist (Garesfield) said that Mr. Kirkup mentioned the use of exhaust-steam, which went through the flues of the drying-floors to the chimney after coursing under the flat-sheets. He did not advocate drying lumps or quarls in that way, but in a flat covered with quarls or cement, and for ordinary fire-bricks it was an economical method. Mr. Kirkup's paper evidently referred to the use of very small kilns. Those generally adopted on Tyneside were much larger, containing from 11,000 to 12,000 bricks, and by adopting these larger kilns higher relative economy was to be found, both in regard to the first cost and to the consumption of fuel. He had had some experience with the patent fires invented by Mr. Kirkup, and he could confirm the writer's figures as to the large saving in the consumption of fuel. He had also found that the bricks were very much more uniformly burned, and that the bricks burned in the front of the kilns were not hard and discoloured, but were of a uniform quality throughout.

Mr. Cochran Carr (Benwell) said he had experimented with hot-air furnaces, but the experiments had been made with larger kilns than those mentioned in the paper, for they contained about 12,000 bricks, and the results were better than those mentioned by Mr. Kirkup, the economy of coal being very marked. With respect to the weathering of fire-clay, he did not think it was a safe principle that weathering was good for all clays, especially those which contained silica, and he thought that the higher the proportion of silica the less was the clay improved by weathering. He had obtained the following results showing the economy derived from the adoption of the improved furnaces as compared with kilns fired in the ordinary way. A kiln fitted with common open fires containing 10,050 bricks ($2\frac{1}{2}$ inches) burnt $8\frac{1}{2}$ tons of coal, or 16·91 cwts. per 1,000. The improved furnaces were fitted to a kiln of the

same dimensions and loaded with 11,750 bricks (2½ inches); the fuel consumed was 6·8 tons, or 11·57 cwts. per 1,000, effecting a saving of 5·34 cwts. per 1,000, or 31½ per cent. The bricks were thoroughly well burnt and highly satisfactory.

Mr. Wm. Cochrane (Newcastle-upon-Tyne) asked whether the author had had any experience of moulding fire-bricks by machinery. He would also like to ask the author whether he was aware of any machine being used in the county of Durham for manufacturing fire-bricks.

Mr. W. C. Blackett (Durham) referred to the author's experience of the use of iron flat-sheets, and said that they had been used at the collieries under his charge for drying ordinary bricks, and on the whole had given satisfaction. If anything, the bricks received too great a heat, and this distorted the shape of the brick by making it a little smaller on the heated side. In the case of heating the flats with exhaust-steam, the bricks did not go on drying with the same heat during the night, when the engine was stopped, as during the day. He had a drying-flat made of quarls, covered with a fine layer of cement. The brick-burner seemed to like the quarls and cement as well as the iron flat-sheets, and when questioned as to the rapidity of drying, he stated that he got as many dried bricks from the one as from the other, the quarls maintaining the heat more uniformly during the night, when the steam was off. He (Mr. Blackett) was concerned to find the other day, however, that the cast-iron sheets were beginning to pit-off and lift away with the bricks. It would seem as though the bricks on the under-surface, being moist, were rusting the surface of the iron, and this united with the clay, and, if the bricks had been of a good quality, would no doubt have spoiled them.

Mr. Jeremiah Head (London) said that Mr. Kirkup, in his paper, mentioned a heat of 3,000° Fahr. Would he kindly tell him, in his reply, whether he had ascertained this heat from actual testing by any means, and if so, what means he had employed to ascertain such high temperatures?

Mr. Cochran Carr stated that he had tried iron flat-sheets as mentioned by Mr. Blackett, and after 2 years use he had found the iron surface to peel off in the same way. He, however, found that a coating of about 2 inches of cement was very effective in preventing this deterioration.

Mr. R. L. Weeks (Willington) stated that Messrs. Straker & Love were making fire-bricks by machinery at their collieries. They were

taken direct from the machine to the kiln, and, so far as he could judge, testing them in the forge, the hand-made and the machine-made fire-bricks compared equally well. The clay was used in a semi-plastic state.

Mr. Thomas Douglas (Darlington), in reference to Table IV., gathered that the gain of 4·65d. per ton was accounted for by crediting the coal-cost of No. 1 system with 2s. 2¼d. per ton for labour on the clay produced. They had therefore 2s. 2¼d. to begin with, and he assumed that Mr. Kirkup found on adding to this amount the further cost involved for manufacturing, rents, etc., that fire-clay works could be carried on to profit.

Mr. T. W. Benson (Newcastle-upon-Tyne) asked whether the 22½ cwts. of coal per 1,000 bricks, alluded to, was for burning alone. If so, he could not help thinking that it seemed extremely high when compared with the consumption of any ordinary kiln. His experience with an ordinary Newcastle kiln, 14 feet by 14 feet and 9 feet high, producing 11,000 bricks, was that the fuel for burning alone was about 16 cwts. per 1,000 bricks, and for drying about 5 cwts., and the fuel for the grinding process about 3 cwts., making altogether about 24 cwts. of fuel, or very little more for the whole process than Mr. Kirkup seemed to have used for burning alone. Of course, something depended upon the nature of the coal, but he took it that Mr. Kirkup had used the same coal in an ordinary kiln as in his experiments in the improved kiln. He had found in treating the hard clay of the Brockwell coal-seam that the use of the Blake stone-breaker was extremely economical. It enabled them to pass a much greater quantity of material through the mill, and also greatly saved the rollers, which would soon wear in crushing hard clay. He had used a Blake machine for 17 years with very little repairs, and the jaws had recently been renewed for the first time, while each pair of edge-stone hoops only lasted about 2½ years.

Mr. P. Kirkup, with regard to Mr. Steavenson's remarks about ganister bricks, stated that the object of his paper was to show how the under-clays of the thin coal-seams might be utilized for some purposes, whereby the colliery-owner might be enabled to work his coal more cheaply. As ganister was seldom associated with coal-seams, he had not thought it competent to bring it into his treatise. As regards the analyses referred to by Mr. Steavenson, he asked Mr. Stock, who had had a very large experience in Durham fire-clays, whether he would give him some typical analyses of Durham clays. He (Mr. Kirkup) had several by him, but he wanted to be sure that they were typical ones. That gentleman had

kindly given him the list as printed in the paper. With regard to drying bricks on iron flat-sheets, he had not had actual experience in drying bricks by this method, but he gathered from what he had seen that there was a great danger of oxidation, and as fire-bricks were required, at any rate, to be of a presentable white colour, and many firms staked their reputation on the colour of the brick, he thought that it would rather militate against its value if it partook of the iron. Simply mixing, as he had no doubt it would, with the ingredients, it would have a tendency to discolour them. Moreover, the oxidation went on very rapidly, and he was afraid that the exhaust-steam would penetrate in some measure through the joints of the flat-sheets, and rather do away with the good effect of the heat.

With regard to the larger sized kiln, he might say that the bricks he referred to were very hard burned, and with the common fires they had to adopt a kiln 15 feet by 10 feet. He believed that many of the kilns used for burning fire-bricks on Tyneside were larger than those mentioned in his paper; and he agreed that relatively there would be greater economy in the larger-sized kiln, especially if the furnaces were fed with hot air. Bricks made from rich clays require careful burning, and therefore the character of the clay, and the purpose to which the goods are to be ultimately used, should in some measure determine the size of the kilns. At the works under his charge the bricks were made from clay high in alumina, and it was found necessary to steam and burn a kiln for 8 days; whereas, on Tyneside, where the clays are more siliceous, 6 days' steaming and burning was generally sufficient.

He had not had actual experience with regard to machine-made bricks, but was simply speaking from what he had heard. He was very doubtful, however, with the machinery at present in the market, that satisfactory fire-bricks could be moulded by mechanical means, but he would be pleased to hear of a machine for this purpose, as a considerable saving might be effected as compared with the cost of bricks moulded by hand.

The temperatures of the kilns had been estimated by a simple method known as the "immersion-thermometer," described in Mr. Box's *Practical Treatise on Heat*. The method consists in heating a mass of wrought iron to the unknown temperature, immersing it in a known weight of water, and observing the increase of temperature produced. Thus:—Let 5 lbs. of wrought iron, which has been heated to the unknown temperature (in this case the heat of the kiln), be plunged into 10 lbs. of water at 60° Fahr., heating it thereby to 180° Fahr. Then $(180° - 60°) \times 10$ pounds, shows that 1,200 units of heat have

been given out by the 5 pounds of iron, or (1,200 ÷ 5) 240 units per pound. The specific heat of wrought iron being equal to one-ninth that of water, it must have cooled (240 × 9) 2,160° Fahr., and the unknown temperature must therefore have been (2,160° + 180°) 2,340° Fahr. We therefore have the following formula :—

$$T' = \left(\frac{(T - t) \times W}{w} \times 9\right) + T,$$

in which t is the temperature of the water before immersion ; T, the temperature of the water after immersion ; T′, the unknown temperature required ; W, the weight of the water in pounds ; and w, the weight of the wrought iron in pounds. He (Mr Kirkup) had frequently used this method, and although not absolutely reliable, it gave a good estimate of the heat of the gases in kilns and coke-oven flues. The sources of inaccuracy in this method are chiefly the variable specific heat of wrought iron and water ; but, notwithstanding, it is perhaps the best practical method we have of ascertaining temperatures beyond the range of the mercurial thermometer.

As regards the cost of working clay, referred to by Mr. Douglas, he had taken a typical case. They all knew in this district that there was such a thing as a county-average wage for hewers, and assuming that the hewer could make the county-average wage, he was able to do so under the prices and conditions existing in column 1 of Table IV. In column 2, he was able to make very much more wage if he was allowed to send to bank the clay which formed part of his labour of bottom-cutting ; and, therefore, the additional facility afforded to the hewer in being allowed to send out the clay, the product of bottom-cutting, enabled the owner to save £19 7s. 6d. on an output of 200 tons of clay and 1,000 tons of coal sent to bank ; the hewer being able under the improved conditions to earn the same wages with less coal prices than if he had to deal with the bottom-cutting as rubbish.

With regard to Mr. Benson's remarks as to the consumption of 22½ cwts. of coal per 1,000 bricks as originally used, this might certainly appear to any outsider as a large quantity ; but, as he had observed before, the bricks were burned very hard, and the kilns were under fire for 8 days. The coal used was very inferior, but this applied equally to both cases. The consumption of 13¼ cwts. per 1,000 bricks was also of very inferior coal.

The PRESIDENT moved a vote of thanks to Mr. Kirkup for his paper, and this was cordially agreed to.

The following paper was read by Mr. JOHN MORISON, on "Coal-shipping by Belts":—

COAL-SHIPPING BY BELTS.

By JOHN MORISON.

The question of the rapid shipment of coal, with a minimum of breakage, is one of such vital importance to coal-owners, harbour authorities, and others, that the writer offers his experience of a new method of shipment with some confidence that it will prove of interest to the members. In doing so, he would venture to submit that a change from existing methods is so much to be desired, that every encouragement and facility should be given by those interested for the promotion of improved methods.

That the problem of improved methods of shipment is a very difficult one is proved by the continued existence of methods which are the same to-day as they were 50 years ago. The methods in general use are, so far as the writer is conversant with them, of the following descriptions :—

(*a*) The drop, in which the coal-waggon with bottom-boards is lowered against a balance-weight down to the level of the ship's hatchway and there discharged *en masse* by releasing the bottom-boards, the coal falling a distance varying from the full depth of the hold to the reduced distance consequent upon the heaping up of the coal in the hold.

(*b*) The spout, in which the coal is discharged from the waggons at a high level and gravitates down an inclined spout or shoot to the ship's hatchway, where it is controlled by a trap and is discharged into the ship, falling a similar distance to that which obtains in the case of the drop.

(*c*) The crane, in which the waggon is lifted on a cradle by hydraulic, steam, or other power from quay-level, and is swung round and discharged at, or occasionally a little below the combings of the hatchway.

(*d*) The hydraulic crane, in which the waggon is run on to a cage or platform, elevated to a shoot, and there discharged, the coal gravitating down the shoot to the hatchway, as in the case of the spout arrangement.

In addition to these systems, there are modifications of the general arrangements described in occasional use, and there are also several exceptional arrangements which represent the attempts which have been

made to deal with the subject on a new basis. These attempts, in all instances which have come under the writer's observation, are so modern, and the result is so difficult to judge, that there is no generally pronounced opinion that any one system has effected a very marked improvement upon the older systems. Whilst this is so, however, there is little doubt that, although the results have not been generally acknowledged, in several of the modern attempts which have been referred to, causes of breakage have been removed, which must tend to reduce the breakage and to improve the condition of the coal.

Adverting to the systems generally in use, the writer is of opinion that the most desirable of the old arrangements, in so far as saving of breakage is concerned, are the drop and the crane, as in both these arrangements two causes of breakage are absent which prevail in other arrangements, viz., the discharge into a spout and the attrition of the coal in the spout. Both arrangements, however, lack that rapidity in shipment which is demanded, and in both there is also serious breakage of the coal until shipment has proceeded to a stage where the waggon can discharge on to a heap, with less fall than that to which it is subjected in the earlier stages of shipment.

With regard to speed of shipment, it may be taken for granted that no system is acceptable unless it fulfils the demand of the shipowner for rapid despatch: and it is to be feared that this demand stands more than anything else in the way of improvements in the methods of shipment so far as breakage is concerned.

Before describing the arrangement of belts which is the subject of this paper, it seems desirable to summarize the points which tend to the breakage of coal in existing systems. The chief causes of breakage in shipment are:—(1) The fall from a waggon into a shoot, the fall being increased by the angle of inclination of the shoot; (2) the attrition of the coal in the shoot and the breakage caused by impact of coal on coal as it slides down the shoot, especially if the trap be neglected; and (3) the fall of the coal from the hatchway into the ship.

The following is a description of the Wrightson coal-shipper:—As shown by the accompanying plans (Figs. 1, 2, and 3, Plate II.), the machine is constructed with two conveying-belts *A* and *B*, and one vertical belt *C* fitted with trays *a*, which lower the coal into the hold. The first belt *A* is carried horizontally upon a frame which forms the basis and foundation of the machine.

At the end of the belt *A*, an upright frame *D* is socketed in the centre, at the bottom *b*, into the frame and at the top into another socket or bearing *c* carried by stays, the arrangement resembling that of the mast and stays of a derrick-crane. The second belt *B* works as a jib from the pivoted frame, and is supported at its outer end by ropes, wound on to two drums *E* fixed on the pivoted frame *D*. On the end of the jib-belt *B*, and hung on a centre attached to the frame of the belt, is the trunk or vertical belt *C*. The entire machine is mounted on wheels, and can be run away from or towards the ship as required.

All the movements are obtained from an engine *F* of semi-portable type, which is seated on the back of the machine, the power being conveyed by a horizontal shaft *d* and a vertical shaft *e*, from which all the movements are derived by suitable chain or gear-wheels. The motion of the vertical trays *a* is transmitted by the links of the conveying-belt *B*, and by chain-wheels from the outer drum-shaft *f*, to the drum-shaft *g* and the vertical belt *C*.

By an ingenious arrangement, the vertical shaft *e* is placed concentric to all the movements of which the jib is capable.

The movements conveyed from the engine are as follows:—(1) The machine may be travelled in and out, to and from its work; (2) the conveying-belts *A* and *B* can be put in motion; and (3) the jib-belt *B* may be put into motion or may be raised or lowered, or swung horizontally, with a range of 9 feet on each side of its centre—*i.e.*, with a total lateral range of 18 feet. All these movements may be made simultaneously, or separately, as desired, by means of clutches on the various movements.

In working, the belts *A* and *B* are geared to different speeds, for the purpose of obtaining a regular distribution of the coal into the trays *a* on the trunk-belt *C*. The belt *A* is driven at 40 feet per minute, the jib-belt *B* at 60 feet per minute, and the trunk-belt *C* at 80 feet per minute.

The waggons are brought in at a high level, and discharge from the bottom into a hopper, the bottom of which is formed by the plates of the belt *A*. This hopper has been made of such size that, when a waggon of coal is discharged, the coal chokes the hopper, and consequently the fall to which it is subjected is minimized. The coal leaves the waggon, after choking on the heap, at such a speed as the speed of the conveying-belt *A* permits, the depth of coal on the belt being regulated by a fixed trap on the outside of the hopper. This trap permits the belt to load to a depth of 18 inches. The coal is carried along the belt *A* in a stream 4 feet wide by 18 inches deep, the jib-belt *B* being set to suit the ship, and

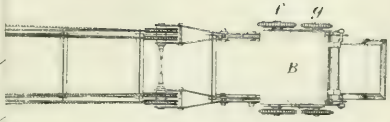
with the trunk-belt C placed in the hold, the stream is continued on to the jib-belt *B*, and from it delivered on to the trunk-belt *C*.

The possible causes of breakage to which the coal is subjected from the time it leaves the waggon are :—(1) in discharging from the waggon to the hopper ; (2) in being transferred from the first belt to the jib-belt ; (3) in being discharged from the jib-belt on to the trunk-belt ; and (4) in being discharged from the trunk-belt on to the heap in the ship's hold.

The conclusions which the writer has formed from observation of the working of the machine over several months are as follows :—(1) In discharging from the waggon on to the belt, there is necessarily some breakage, but this is minimized when compared with the hopper connected with an ordinary shoot by the shallow hopper with a level bottom. The coal appears on the first belt with no apparent change in its condition, although there must of necessity be some alteration. (2) In being conveyed along the first belt, all the damage caused by the friction and rolling in a spout, and the damage caused by improper manipulation of the trap is avoided. (3) In changing from one belt to another, there is no apparent breakage, the coal flowing quietly from one belt to the other in a steady stream and without apparent fall. The condition of the coal on the jib-belt is apparently identical with its condition on the first belt. (4) In delivering from the jib-belt into the trunk, a fall is inevitable and damage occurs ; this can be traced, to a certain extent, in the appearance of the coal in the trunk as compared with its appearance on the jib-belt. (5) In discharging from the trunk into the hold, the coal is poured on to the heap with a very slight fall, and no appreciable damage is sustained. (6) In the writer's opinion, which is formed from watching many ships while loading and some discharging after their voyage, there is considerable improvement in the condition of the coal as compared with the old system of spout-shipping.

In putting the first of a cargo into a ship, the wholesale breakage which is occasioned by the fall from the spout is avoided. The coal which is subjected to this treatment forms a considerable portion of the cargo, and the first of it (in discharging into the hold from a spout) is broken to dust. A considerable quantity of duff is also formed during the whole course of the shipment by the rubbing of the coal on the shoots, and a considerable part of the damage due to these causes is manifestly avoided in the belt-system.

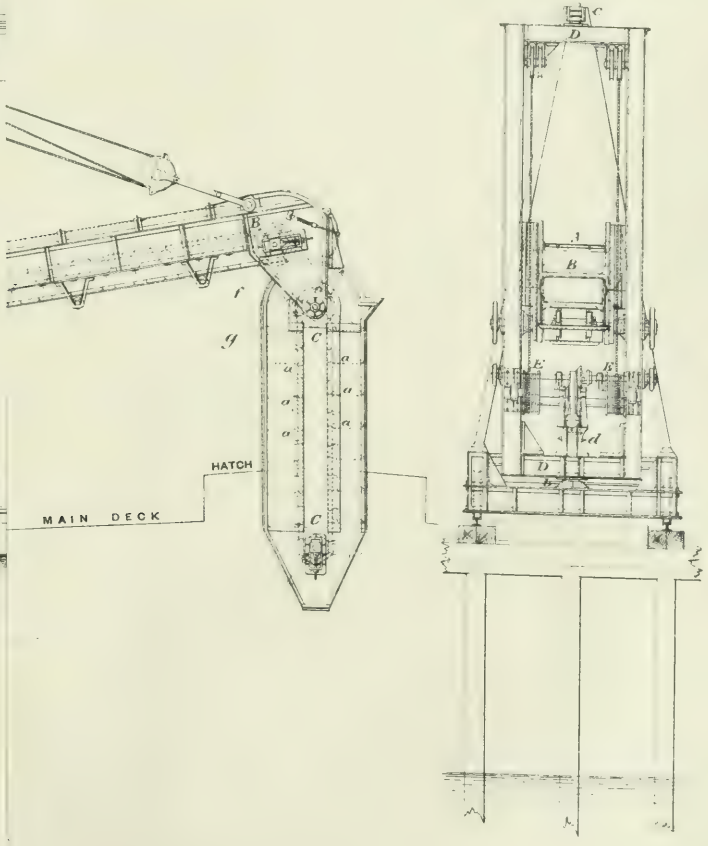
The machine is now working as it was first designed and constructed, and up to the present time no alterations have been made in the original



EXIS

FIG. 3.

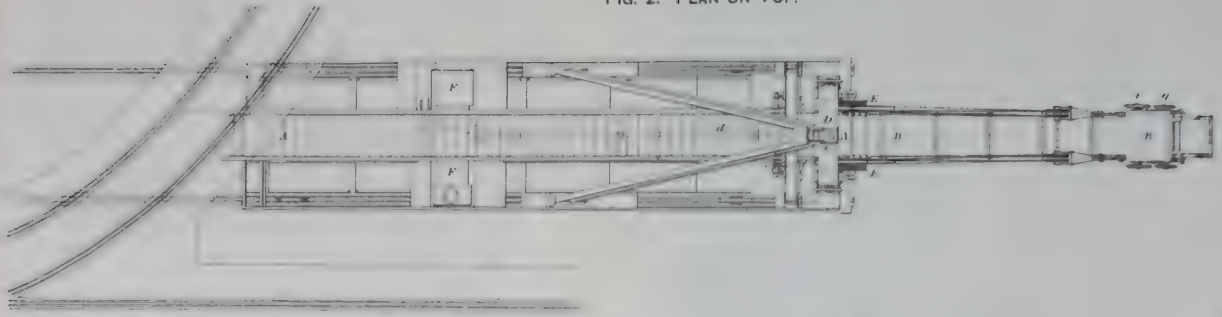
SECTIONAL ELEVATION THROUGH Y. Z.



Feet to 1 Inch.

North

FIG. 2.—PLAN ON TOP.



EXISTING STAITHE

FIG. 1.—SIDE ELEVATION

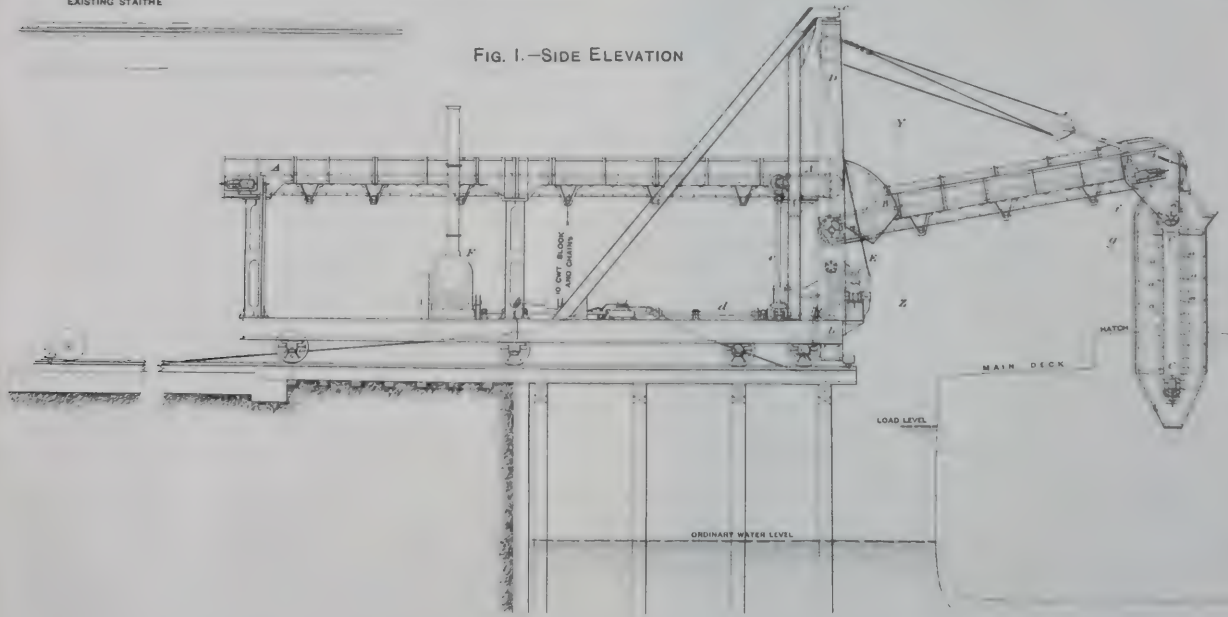
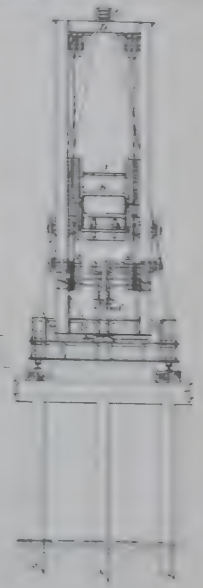


FIG. 3.
SECTIONAL ELEVATION THROUGH Y Z



Scale, 12 Feet to 1 Inch

design, although experience has pointed to many possible improvements. Schemes for these are under consideration, but they need not be referred to further at present.

The machine was adopted by the directors of the Cramlington Coal Company as a serious attempt to deal with the breakage of their coal in shipment, and it has so far realized expectations that they intend to continue it and to endeavour to perfect the system.

The quantity which can be removed by the present machine has been found to be a 4 tons waggon in 30 seconds, or at the rate of 480 tons an hour. With a wider belt and a greater depth of coal, both of which are quite practicable, there would be no difficulty in removing even larger quantities.

The present arrangement of gangways has up to the time of writing this paper been inadequate for supplying more than 230 tons an hour to the machine, and it is at present in course of alteration to enable the waggons to satisfy the capacity of the machine. It is, therefore, amply demonstrated that the question of rapidity of shipment does not arise, and with regard to the lessening of breakage, the writer is of opinion that the machine is upon the right lines for solving a very difficult problem.

Mr. E. W. Crone read the following paper on a "Telescopic Spout for Saving Breakage of Coal in the First Shipment":—

TELESCOPIC SPOUT FOR SAVING BREAKAGE OF COAL IN THE FIRST SHIPMENT.

By E. W. CRONE.

In late years, there has been great difficulty in preventing the coals that are first placed on board ship from being broken and crushed into small pieces (and a portion becoming practically duff) in the hold of the vessel, in a direct line below the hatchways.

The following is a description of a telescopic spout in use at the Wallsend coal-shipping staithes for preventing this breakage of coal in the first portions shipped:—

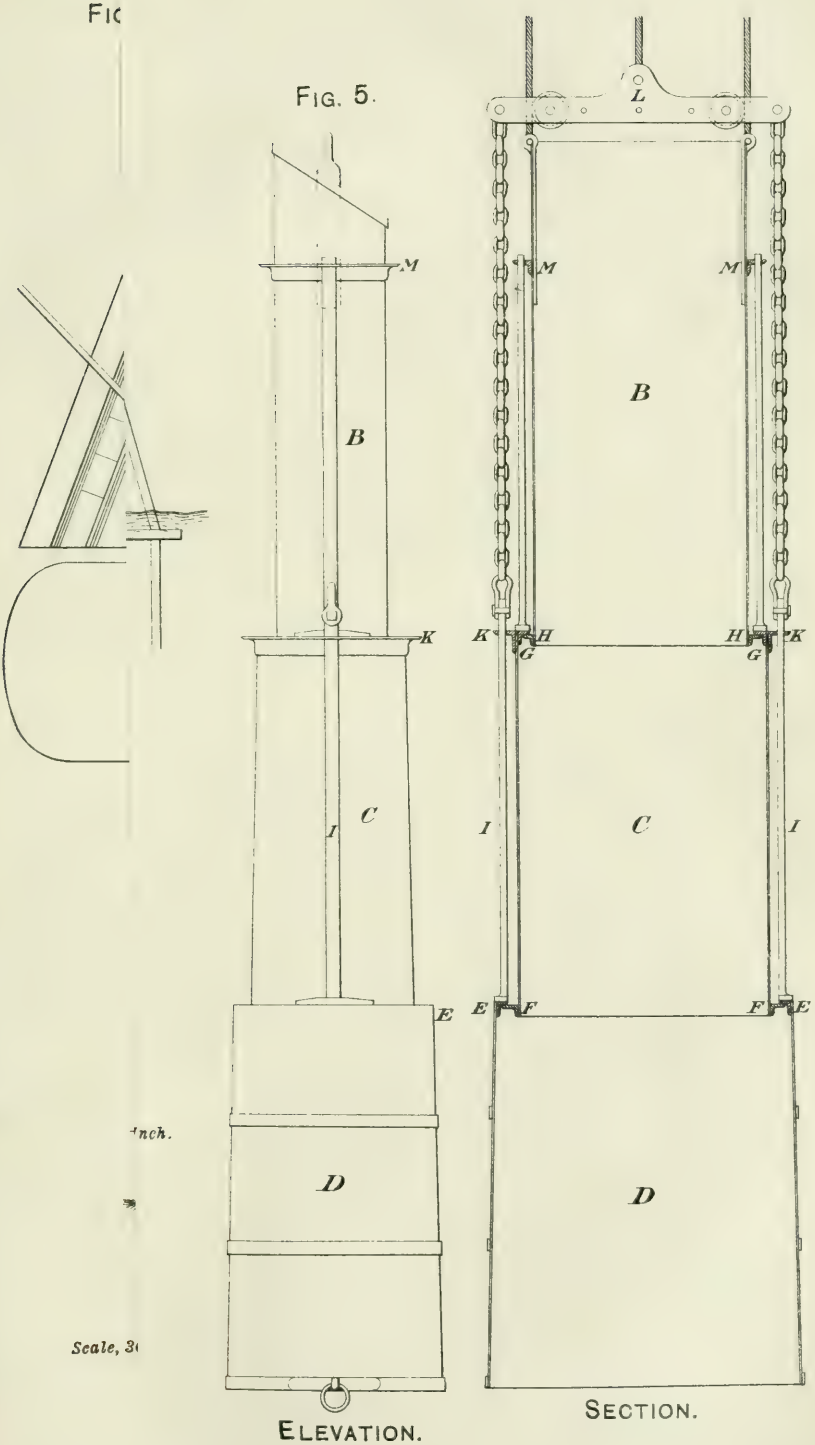
The Wallsend staithes are a range of three fixed spouts four tiers in each, at a distance of 45 feet apart, sloping at an angle of 40 degrees. A swinging spout *A*, is attached to these, and reaches from the front of the fixed spouts, to the centre of the hatchway of the vessel, and is raised or lowered by winches as the tide rises and falls (Figs. 1, 2, and 3, Plate III.).

Formerly, the vessels were loaded through the swinging spout, direct into the vessel's hold, and in vessels of various tonnage, the holds were of various depths. In the process of filling up to each hatchway there was a great deal of breakage, and the deeper the vessel's hold the more breakage and crushing of coal there was. On many occasions there were complaints from buyers of the smallness of the coals in that portion of the vessel's hold, before-mentioned, when discharging the cargo. This telescopic spout was designed to avoid these breakages.

The telescopic spout consists of three sections *B*, *C*, and *D*, which may be of any length (Figs. 4, 5, and 6, Plate III.). The lower section *D* is made with an internal angle-ring *E*, *E* at the top of its length, which, in the extended position, rests upon an external ring *F*, *F* at the lower end of section *C*. The sections *C* and *B* engage in a similar way by the rings *G*, *G* and *H*, *H*. Guide-bars *I*, *I* are fixed on the upper part of section *D* passing upwards through an external ring *K*, *K* placed on the top of section *C*, attached by chains to a crossbar *L* suspended from a steam-crane. Similar bars pass through an external ring at *M*, *M* on section *B*. The upper section *B* is suspended independently by ropes from the same crane.

FIG. 4.

FIG. 5.



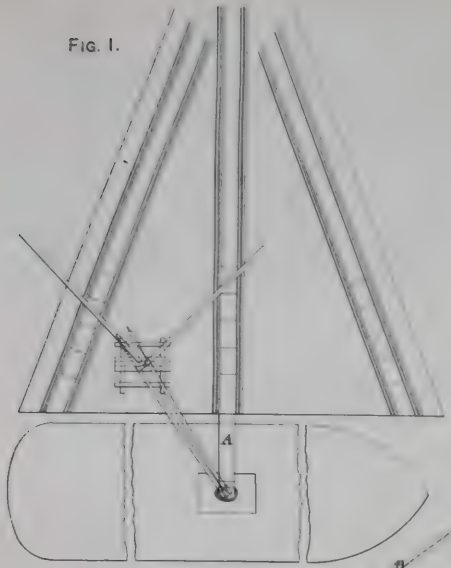
ELEVATION.

SECTION.

...nch.

Scale, 3...

FIG. 1.

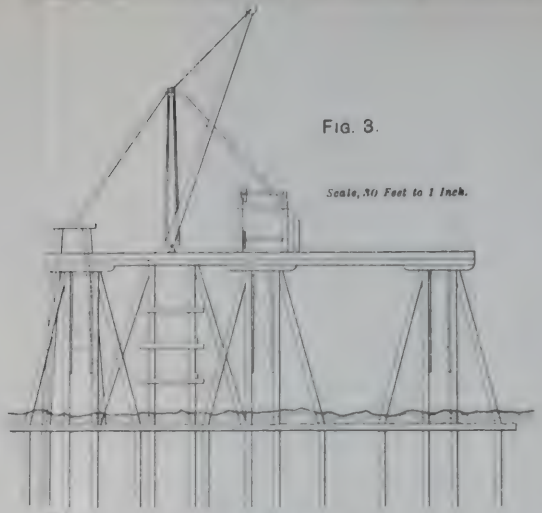


PLAN.

Scale, 30 Feet to 1 Inch.

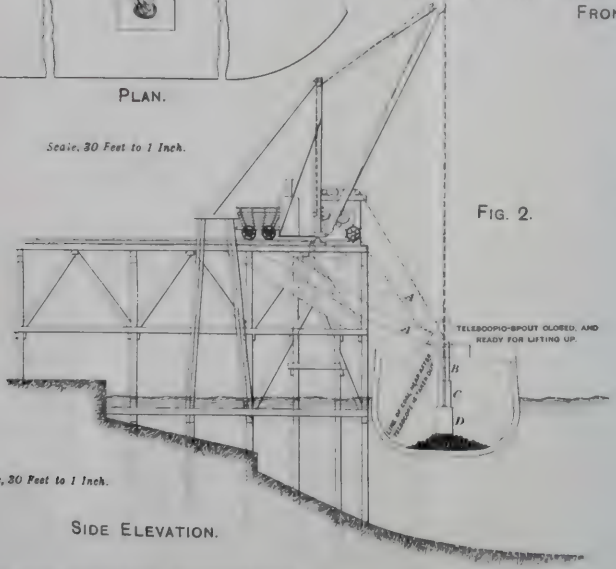
FIG. 3.

Scale, 30 Feet to 1 Inch.



FRONT ELEVATION.

FIG. 2.



Scale, 30 Feet to 1 Inch.

SIDE ELEVATION.

FIG. 6.

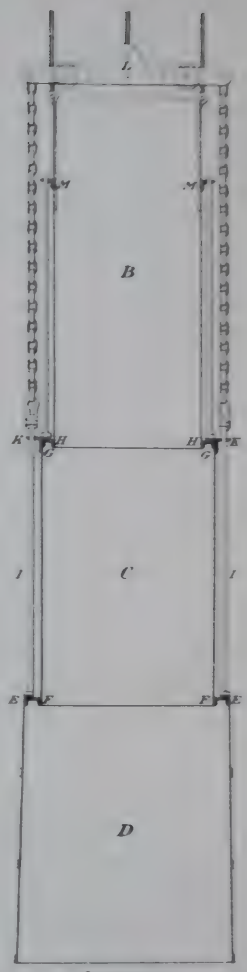
PLAN.

Scale, 3 Feet to 1 Inch.

FIG. 5

ELEVATION.

FIG. 4.



SECTION.

The top part of section *B* is brought immediately under the outer end of the swinging spout *A* (Fig. 2, Plate III.), to which it is secured by light chains, to keep it in position for loading. The telescope is then run down into the hold of the vessel, by lowering the main chain of the crane. Coals are then teamed in the usual way until the spouts are filled up to the waggon. The lowest section *D* is then lifted by the crane sufficiently to allow the coals to flow gently into the vessel's hold. In loading, the craneman watches the coal in the swinging spout *A*, and regulates the lifting of the telescopic spout, *B*, *C*, and *D*, by keeping the swinging spout, *A*, full of coal, until the heap is up to the hatches. By this mode of shipping, 250 tons of coal can be placed in the vessel's hold in one hour.

After the heap of coals in the vessel's hold is run up to or near the level of the hatchways, the telescopic spout is taken out, and loading proceeds as usual.

It is needless to add that the object for which this telescopic spout was designed has been accompanied with the most satisfactory results.

Mr. H. Richardson's paper was read, on the "Shipment of Coal":—

SHIPMENT OF COAL.

By H. RICHARDSON.

(1) An improved coal-shipping drop now in use by the Tyne Improvement Commissioners for the shipment of Backworth and West Cramlington coals at their No. 4 staithe, Whitehill Point, on the river Tyne, was designed to remedy the difficulty found at other coal-drops in holding ships in position by warps, particularly where loading in rivers or tidal basins, and in adapting the drop system to lofty staithes.

In this drop (Fig. 1, Plate IV.) the waggons may be lowered from almost any height from the staithe-head or railway-level to the ship's deck, or into the hold, upon a cradle *A* by means of a steep incline *B*, worked by a counter-balance weight *C*. *F* is the main drum and brake-sheave, and *G* is the balance-pulley. The incline *B* may be moved, by the two levers *D*, *D*, which are worked by a windlass *E*, out or in from the staithe to suit the position of the hatchway, so that a vessel loading may in all cases be moored alongside the staithe or quay. When not in use, the incline *B* may be drawn out of the way within the front timbers of the staithe, and the ordinary spouts may be substituted for the shipment of unscreened or small coals. The movable external spout is not shown in the plan.

(2) The drop system of shipment is not suitable for waggons of more than 4 tons carrying capacity. For larger waggons, a crane worked by steam or water-power is better adapted, and the effect of these two methods is identical. Most modern steamers are fitted with hatchways and loose cross beams which will admit of $10\frac{1}{2}$ tons trucks being lowered into the hold, for the prevention of coal-breakage. After a cone of sufficient size has been formed on the bottom of the ship, the strengthening beams across the hatchway can be replaced and the loading completed.

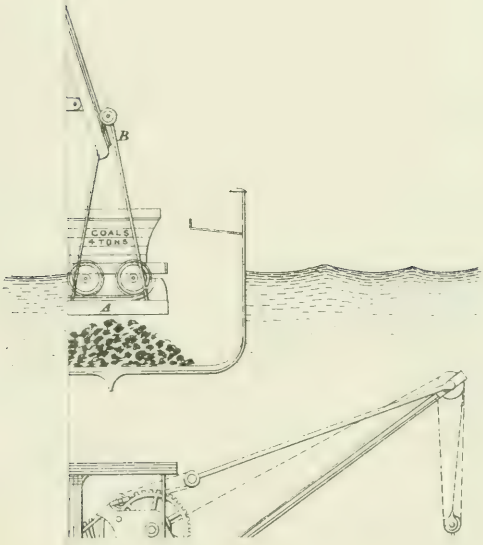
Figs. 2 and 3 (Plate IV.) represent the steam-crane system, with $10\frac{1}{2}$ tons trucks. It will be seen that a staithe is not required, and the trucks are moved to and from the crane cradle by means of capstans and light hempen ropes. The sketches show a coal-shipping crane as used at Ayr, but North-eastern Railway waggons are shown in course of coal-shipment. The waggons used at Ayr are fitted with end-doors, and are different in other respects from those represented in Figs. 2 and 3 (Plate IV.).

About 150 tons of coal an hour may be shipped by the improved drop, and 200 tons an hour by the crane.

Mr. J. M. Moncrieff's notes were read, on "Coal-shipping Plant at Wallsend Colliery":—

nproved Coal-shipping Drop".

FIG. 1.



INSERT

FOLDOUT

HERE

COAL-SHIPPING PLANT AT WALLSEND COLLIERY.

By J. M. MONCRIEFF.

The plant now in operation at Wallsend for the shipment of coal from the newly re-opened Wallsend colliery is at the present date quite unique.

The staithe is connected direct to the colliery-yard by a double line of railway, one full and one empty way. The full way falls from the colliery to the staithe-head with a gradient of about 1 in 70, the waggons gravitating to the staithe-head in sets. The empty way also falls from the colliery for a considerable distance with a steeper gradient than the full way, and it also falls back from the staithe-head, to form a bay for the empty waggons to gather in sets, to be taken back to the colliery-yard by locomotives.

The staithe-head is approximately triangular, the base of the triangle forming the river-frontage. The full and empty ways run one on either side of the staithe-head, and terminate in turntables which are connected by a cross-way falling from the full to the empty way, running parallel to the river-frontage, and carrying the waggons immediately under the hydraulic crane. The turntables swing back automatically to the direction from which the waggons approach, after a waggon has been turned and despatched. The staithe-head is constructed of pitch-pine timber and is carried on piling out to the River Tyne Commissioners' quay-line.

The level of the rails at the river-front is about 42 feet above high-water mark.

The coal is conveyed from the colliery-yard to the staithe-head in steel-plate boxes, each holding 5 tons, resting, without any connexion, on low trucks with light steel frames. These steel boxes are provided with sprocketed trunnions rivetted to their sides. The trunnions engage with pitch-chains passing over sprocket-wheels on a cross shaft, on which are two other sprocket-wheels, from which the box is suspended by loops of pitch-chain attached to the wire ropes of the hydraulic crane, by which the boxes are lifted clear of the waggon-frames, swung out, and lowered into the hatchways of the vessel at the staithe.

These tipping-boxes and the method of tipping were invented by the late Mr. F. G. M. Stoney, and a considerable number of them were in use on the Manchester ship-canal works for the carriage and disposal of dredged material. They appeared so thoroughly well fitted for use as anti-breakage boxes in the shipment of coal, that Messrs. Sandeman &

Moncrieff had no hesitation in recommending their adoption for the first time for this purpose, and these gentlemen were instructed to prepare a scheme of coal-shipment suitable to the local conditions and requirements of the colliery, with special attention to the question of saving of breakage. Under their superintendence, the shipping arrangements, which have now been in operation for a short time, have been carried out. The crane, waggons, and boxes were designed and constructed by Messrs. Ransomes & Rapier, of Ipswich.

High speed of shipment, although of great importance, has in this arrangement been made subservient to handling the coal with the minimum amount of breakage, and in this respect the plant will probably compare favourably with any existing method. At the same time, the question of speed necessarily entered into the requirements under which the crane was constructed, and it was guaranteed to lift the full box off the truck, swing it out to the full range of the jib, lower it through a vertical distance of 74 feet below rail-level, and tip the coal out in 1 minute. The reverse operations were also specified to be completed in 1 minute.

As regards the actual speed of shipment, it is somewhat premature to give figures, as the capacity of the staithe is dependent to a large degree upon the dexterity of the staithemen and craneman and upon the type of vessel. The writer hopes, however, to be able to give some figures at a future date which will enable comparisons to be made with other systems.

Mr. M. H. Mills said that at the present time they were using in Yorkshire an apparatus, similar to that in use at Wallsend colliery, for lowering coal into waggons, but it did not seem to him to be very useful for large shipments.

Mr. H. Ayton said it was stated in the paper that a waggon carrying 5 tons of coal could be shipped in 2 minutes, or at the rate of 150 tons an hour.

The President stated that the three systems referred to in the papers would be seen in operation during their visits on the following day, and he therefore proposed that the discussion should stand over until the appliances had been seen by the members. He had pleasure in moving votes of thanks to the writers of the papers.

The motion was cordially approved.

Mr. T. E. Forster read his "Historical Notes on Wallsend Colliery":—

HISTORICAL NOTES ON WALLSEND COLLIERY.

By T. E. FORSTER.

There are, perhaps, but few people in this country, as well as in many other parts of the world, who are not familiar with the name of Wallsend: and it is possible that the celebrity which the Tyneside village has attained has been due rather to its association with the coal-trade during past years, than to its connexion with the great engineering work of the Romans, to which it owes its name.

It is hoped, therefore, that a short account of the history of Wallsend colliery may not, at the time of its re-opening after many years of disuse, be uninteresting.

The closing years of last century saw the winning of the Wallsend coal. It was at a period in the history of the Newcastle coal-field when mining operations, which had hitherto been principally confined to comparatively shallow pits near the outcrops, were beginning to creep gradually eastwards along the banks of the Tyne, where the famed High Main coal lay at greater depths, requiring increased capital and increased engineering skill for its winning and working.

The difficulties attending the mining of this deep coal were in those days very considerable. Sinking through and stopping back the shaft-feeders, with the wooden tubbing and the insufficient pumping appliances then in vogue, was of itself a long and costly business. The large number of shafts then required is very striking (at Wallsend, 8 shafts were sunk on a royalty 1,250 acres in extent), due chiefly to the presence of fire-damp, which was met with in considerable quantities, and, coupled with the inadequate means of ventilation, presented further risks of a very serious nature. To these Wallsend was no stranger.

The winning was commenced in 1778 within the western boundary of the Roman fort of Segedunum. The first pit was lost in a quicksand, through which the A pit was eventually sunk by piling, and the coal was won by this and the B pit at a depth of 666 feet, in the year 1781. The piling was eventually secured by Mr. John Buddle, sen., in 1792, by cast-iron tubbing, which is believed to have been its first application for the purpose.* The C and D pits were commenced in 1786, the E pit

* *Vide* paper by Mr. John Buddle in *Transactions of the Natural History Society, of Northumberland and Durham, and Newcastle-upon-Tyne*, 1838, vol. ii., page 309, to which the writer is indebted for the early particulars relating to Wallsend colliery.

was sunk in 1791-3, the F pit completed in 1802, and the G pit subsequently sunk as a separate winning. In all these shafts more or less heavy feeders of water were found (in the C pit as much as 1,700 gallons a minute), generally near the surface. They were, in each case, successfully stopped by means of plank and oak-crib tubbing, so that ultimately one engine with a pumping-set 12 inches in diameter drew the whole of the water-feeders which were principally confined to the shafts.

Glancing at the records of Wallsend colliery, admiration cannot but be felt for the patience and perseverance with which its early difficulties were overcome; for it was not long before the ever-present fire-damp brought disaster upon it. The first explosion occurred in 1783, but was not of a serious nature, one life only being lost, although the workings had to be drowned in order to extinguish an underground fire caused by it. On October 9th, 1785, an explosion took place at the B pit ventilating-furnace, unattended with loss of life, but necessitating the closing of the shafts and a second flooding of the workings, owing to the coal being on fire. The damage done to the B pit shaft was, on this occasion, so great that coal work could not be resumed until after a lapse of 9 months. During the work of re-opening this shaft, 3 separate explosions occurred, causing the loss of 9 lives. These were due to the use of the steel-mill, up till then believed to be safe, and, in consequence of its failure, work was continued in the shaft without it and with the greatest difficulty. For some time it was performed in total darkness, aided only by light reflected from the surface by means of a mirror during periods of sunshine.

After this accident the working of the colliery proceeded without any very serious catastrophe, although explosions occurred in 1786, 1787, and 1803, attended with the loss of 26 lives.

When the coal was first won, there was no intention, owing to the difficulties of ventilation, of removing the pillars, which constituted about 60 per cent. of the seam, though subsequently they were enlarged with a view to their possible extraction in the future.

About 1795, a plan of robbing the pillars was adopted, the workings were divided into districts round which barriers were formed by stowing the boards and walls, the pillars inside being partially worked. This method secured a larger produce, but, as may be imagined, it led to great difficulties and expense through the numerous creeps which it brought on. In 1809, panel-work was introduced, where possible, solid barriers being left round the districts within which the pillars were removed.

FIG. 1.—AIR-SHAFT, WALLSEND COLLIERY.

It must be recollected that all this took place prior to Sir Humphry Davy's great invention of the safety-lamp in 1815, and that the difficulties of working with candles and steel-mills were at times found to be almost insurmountable. In place of the powerful ventilating fan of the present day and carefully arranged systems of ventilation, there were then only small furnaces, fed by the single current of air which had passed round the entire pit and was frequently loaded with gas almost to the firing-point. It was no uncommon occurrence for the sentry, stationed near the furnace, candle in hand, to give the alarm which necessitated the hurried withdrawal of man and beast from the pit and the opening of the main separation-doors in order to prevent an explosion at the furnace. On such occasions, the viewer had no easy task and experienced no little anxiety in relighting the furnace and restoring the ventilation of a mine which no man dared to enter. About 1810, Mr. John Buddle greatly improved matters by splitting the air, and by forming dumb-drifts which conveyed the air from the broken workings into the upcast-shafts without its passing over the furnace.

It was through such dangers and difficulties that the Messrs. Buddle, father and son, steered the course of Wallsend and enabled the colliery to attain the fame and success it acquired. Situated on the banks of the Tyne, the produce commanded ready shipment in the port which, at that date, practically gave the metropolis its coal-supplies, and with the further natural advantages of a thick seam producing coal of a quality which commanded the highest price in the house-coal market, it had a most successful career for many years. This was ended only by the exhaustion of the High Main seam, which was finally closed after the strike of 1831, having then been in operation for a period of exactly half a century.

Prior to this date, the A, C, and G pits had been sunk to the Bensham, and that seam had been opened out with a view to its subsequent working. This seam, however, being a gas coal, although of good quality, necessitated a fresh market, which was not at that time so fully developed as at the present day, or so lucrative as the house-coal trade had proved to be. Added to this were fresh mining difficulties owing to the fiery nature of the seam, bringing upon the undertaking the explosions of 1821, 1835, and 1838, with the heavy loss of 165 lives.

The colliery continued to be worked for some years later, until operations were stopped through an occurrence which affected it, in common with nearly all the surrounding collieries, and ended in the temporary ruin of this great field of mining. This was no less than the

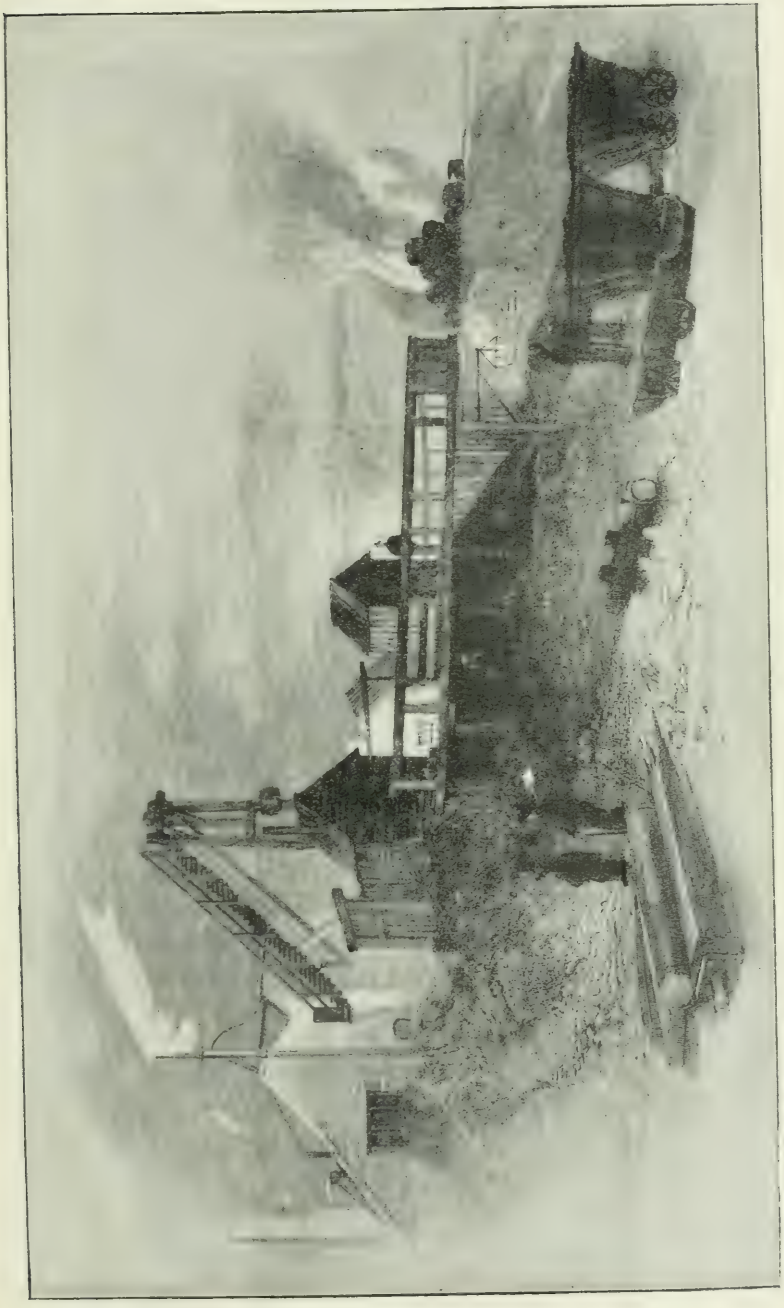


Fig. 2.—C Pit, Wallsend Colliery.

flooding of the Tyne basin, a short description of which may be of some interest. It was primarily due to the gradual exhaustion of the High Main seam, the feeders above which were either tubbed off at the various collieries, as they sank to the lower seams, or were no longer pumped at certain pits.

In 1811, Felling colliery ceased to work the High Main seam and stopped pumping. This compelled the abandonment, in the same year, of the Lawson Main colliery, the water passing also from Felling into St. Anthony's colliery. This water was subsequently pumped in 1823 at the Tyne Main colliery by an engine erected at Friars Goose, and the High Main seam was worked at that colliery till 1842, when it was abandoned and tubbed off, the lower seams being sunk to.

An arrangement was then entered into by the owners of the Tyne Main, Felling, Walker, Wallsend, Willington and Heaton collieries by which they respectively contributed to the cost of keeping the Friars Goose engine at work in case the feeders should pass to the dip. In the meantime, the majority of these collieries had inserted tubbing at the High Main seam in such of the shafts as had been sunk to, or were intended to be sunk to the lower seams, and gave notice of their intention to withdraw from the pumping arrangement. The engine consequently ceased to work in September, 1851, the feeder at that date being 800 gallons a minute.

In March, 1851, Percy Main colliery was laid in, and its feeder of 800 gallons a minute, derived from the eastern extremity of the colliery and from Burdon Main colliery, was also thrown against the dip collieries.

Of these, the first to feel the effect was Jarrow, having contended against the water to the extent of 300 gallons a minute, and having no tubbing.

Wallsend was the next to suffer from water, chiefly through the decayed nature of the tubbing in some of the shafts, and its absence in other shafts which were sunk to the Bensham seam. The water penetrated to this seam, and, through lack of pumping-appliances, the colliery ceased to work in June, 1854.

The neighbouring Willington colliery was next flooded, and, through a similar want of pumping-machinery, was abandoned in February, 1856, to be followed by Bigge's Main in August, 1857. Hebburn was the last to feel the effects of the inundation. In the A and C pits, the High Main water had been tubbed off, and the feeders reduced to 120 gallons a minute, pumped by one engine at the B pit which was only sunk to

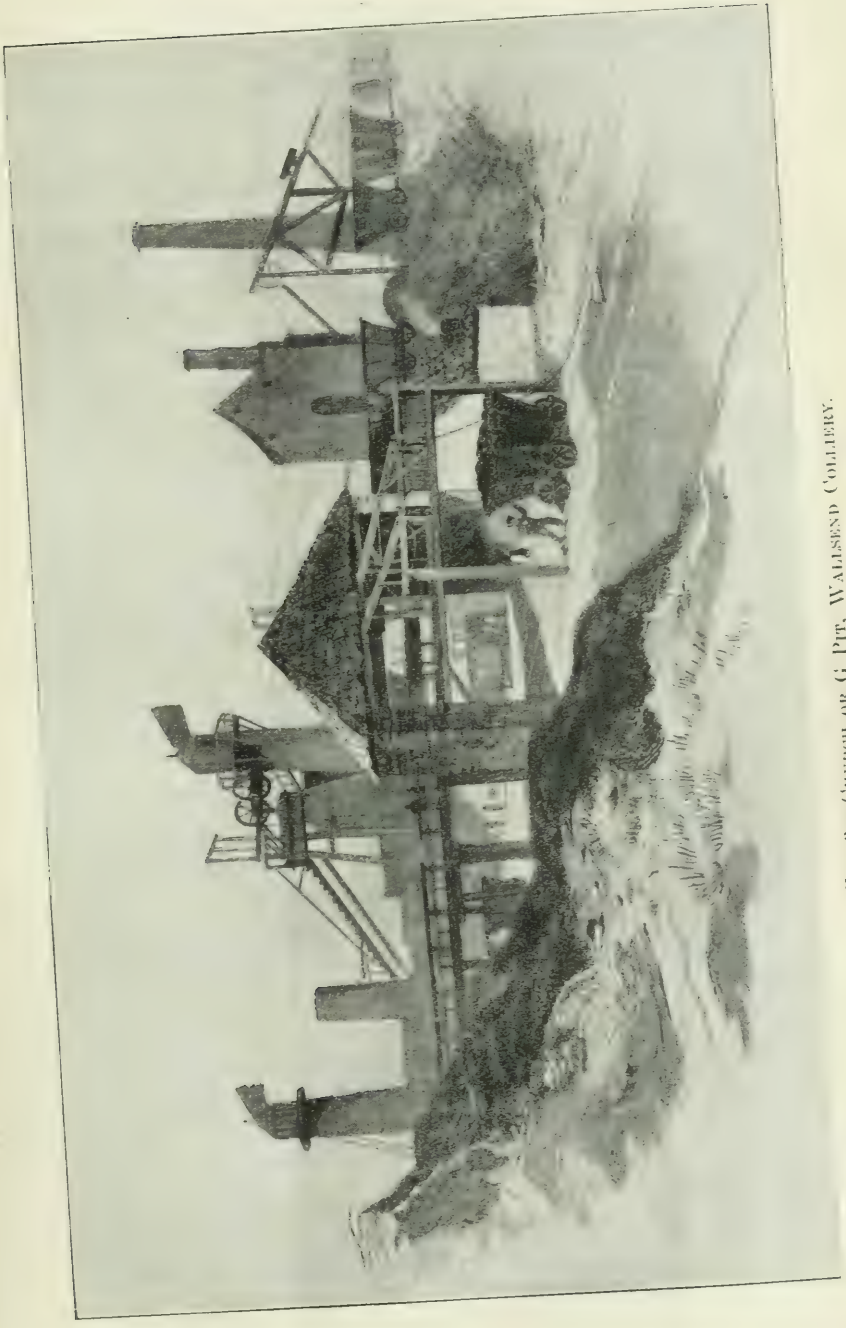


FIG. 3. CHURCH OR G PIT, WALLSEND COLLIERY.

the High Main seam. In 1854, this feeder increased, and a second engine was applied at the B pit in 1857, the feeder being 520 gallons per minute. These engines were, however, unable to cope with the feeder, and were stopped. In the meantime the workings in the Bensham seam had been steadily prosecuted, and the feeders, which had been practically *nil*, gradually increased with the extension of the goaves. The end was now not far distant: under the increased pressure, the tubbing in the C pit commenced to leak in 1858, part of the sheeting having given way, and in May, 1859, it succumbed in the A pit, resulting in the flooding of the colliery.

Walker colliery alone withstood the general disaster. It had been very securely tubbed at the High Main seam, and worked the Low Main seam at a greater depth below its drowned waste than the Bensham seam.

In the meantime schemes for the unwatering and re-opening of this drowned district were being formulated.

In 1855, Messrs. Losh, Wilson, & Bell, of the Walker Ironworks, took the Wallsend colliery with a view to working the Low Main seam, and commenced operations under the direction of Mr. T. E. Forster, by widening out the A pit shaft, originally piled through the quicksand, and thereby decreased to 5 feet 11 inches in diameter, inside which Mr. John Buddle, sen., had set his tubbing in 1792. The enterprise does not seem to have been successful, owing to difficulties with the water, and was abandoned.

In March, 1857, an attempt was made to form the Wallsend and Willington Coal Company, having for its object the re-opening of these collieries, but this proposal apparently was not received with sufficient favour.

It would appear that, by this time, the idea began to be entertained that the undertaking was greater than individual enterprise could hope to grapple with successfully.

Turning to the *Transactions* of the North of England Institute of Mining and Mechanical Engineers, it will be found that later in 1857, Mr. T. J. Taylor read a paper entitled "Suggestions towards a less Local System of Draining Coal Mines."* In this he advocated a scheme for the establishment of three pumping-stations at various points in the Tyne basin, the initial cost of which, he proposed, should be borne by the lessors of the different royalties affected and the cost of maintenance and pumping by the lessees. The feeders to be pumped were then estimated at a little over 4,000 gallons a minute. The outcome of this paper was that in 1861, a bill, known as "The Tyne Coal Drainage Bill," was

* Vol. v., page 135.

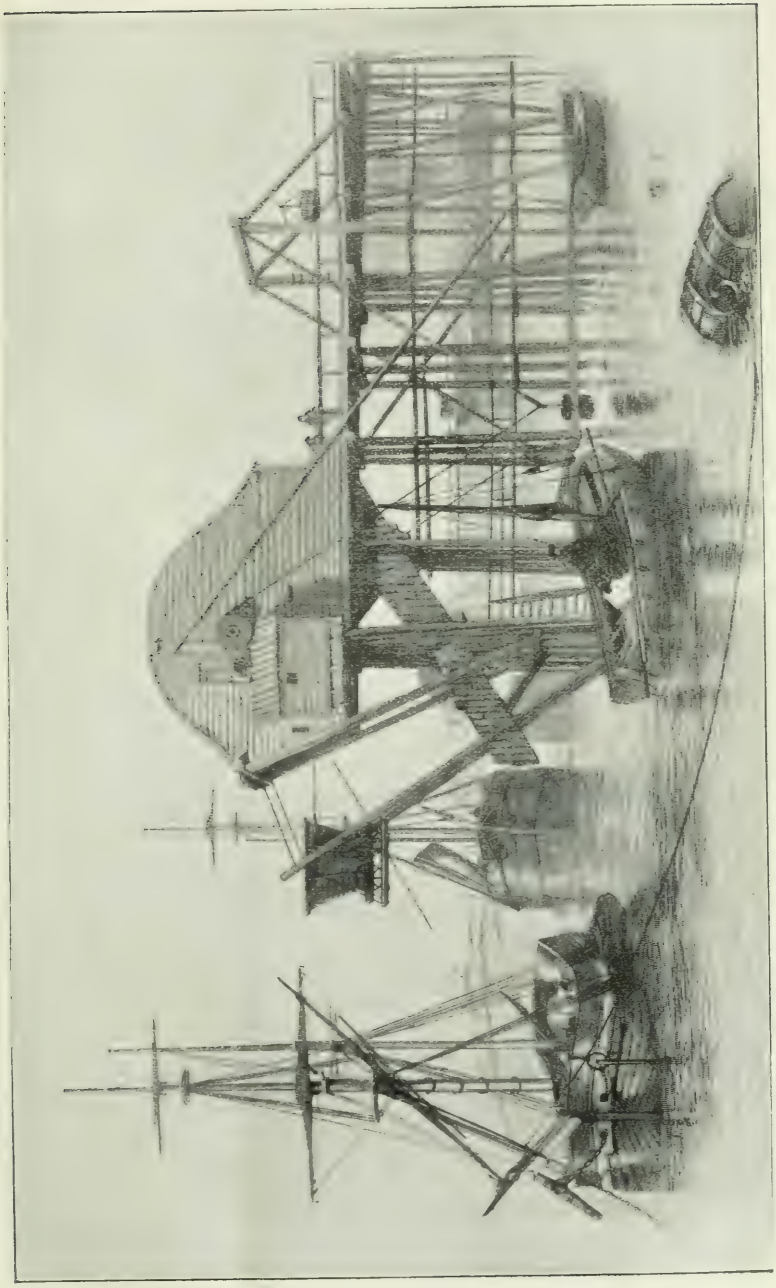


FIG. 4.—COAL-DROPS, WALLSEND COLLIERY.

promoted in Parliament. Owing, however, to differences and objections by some of those whom it was intended to benefit, the bill was withdrawn and matters remained in *statu quo*.

Nothing further was done till 1863, when a proposal was set on foot for the formation of the Tyne Coal Company. This attempt was carried through successfully, and the new company acquired leases of the royalties formerly attached to Hebburn, Wallsend, Willington, and parts of Jarrow and Percy Main collieries. Operations were then commenced at Wallsend and Hebburn with a view to the unwatering of these collieries.

At Wallsend, two powerful temporary pumping-engines were placed on the G pit and commenced to pump in November, 1867. In 12 months' time they had succeeded in lowering the water to a depth of 330 feet, affecting to a considerable extent the levels of the water at Willington, Heaton and Walker, and, to a much smaller degree, those of Friars Goose, Lawson Main, Percy Main and Flatworth. A new pumping-shaft was also sunk to this depth and a large cornish engine erected on it. At Hebburn, water was drawn in tubs at the A pit, commencing in December, 1867, and reaching a depth of 444 feet within 12 months, while a large cornish engine was erected at the B pit to pump the High Main feeders. This work was directed by Mr. J. B. Simpson, who succeeded in freeing Hebburn from water and in establishing it once more as a going concern in the year 1870. From this date, Hebburn continued to be worked, the High Main feeders being pumped by the B pit engine and those from the lower seams by an underground engine, erected at a later date, the Wallsend pumps holding the water at the level reached in 1868.

No further effort was made towards the unwatering of Wallsend till the present company acquired the royalties in 1892, twenty-five years after the project was initiated. As an account of its proceedings is to be given by another writer, this memoir may fittingly terminate here.

The attached illustrations have been reproduced from Mr. T. H. Hair's *Sketches of the Coal-mines of Northumberland and Durham*, 1839.

The writer feels that the general interest which appears to be entertained with regard to Wallsend must be his excuse for having entered at such length on its history, and can only conclude by expressing the hope that the patient and long continued efforts for its rewinning may be rewarded by its renewed prosperity in the future.

Mr. H. Ayton read a paper on "The Re-opening of Wallsend Colliery":—

THE RE-OPENING OF WALLSEND COLLIERY.

By HENRY AYTON.

So much has been written at various times on the Wallsend pits since 1781, when the first or A pit was sunk, that the writer does not propose to touch more upon their history than that part which relates to the G and H pits, where the work of re-opening has been going on.

About the year 1863, when the late Tyne Coal Company, Limited, took over the Wallsend and Hebburn collieries, there existed only the G (or Church) pit on the site of the present operations, and the Hebburn pits were then drowned. Steps were immediately taken to drain the Hebburn pits, and at the same time operations at Wallsend were commenced, not only to pump the water down in the G pit, but towards sinking a new and larger shaft (17½ feet in diameter) some 105 feet distant to the south-east.

Two horizontal pumping-engines were erected at the G pit, each driving two lifting-sets (21 inches in diameter), with a stroke of 6 feet. At the H pit, a large engine-house was erected for the accommodation of two sister cornish engines with cylinders 100 inches in diameter, and a stroke of 11 feet, each capable of pumping 2,000 gallons per minute from a depth of 942 feet. One of these engines only was erected, and was attached to a forcing-set, 26 inches in diameter, with a stroke of 11 feet.

On the water in the G pit being lowered to a depth of 324 feet from the surface, and the H pit having reached a depth of 378 feet (Fig. 1, Plate V.), a drift *A* was driven between the two pits at the higher level and the main-feeder was allowed to flow to the top-set of the then new cornish engine. When matters went thus far, the work of sinking was discontinued, but the cornish engine continued to be worked, and the G pit engines, which were still available to pump to the surface, were employed when required to keep the water down during the changing of the clacks of the H pit pump. From this date (1873), practically nothing more was done till the early part of 1892, when the concern was taken over by the Wallsend and Hebburn Coal Company, Limited, with the object not only of carrying on the Hebburn pits, but in conjunction with them of re-opening the Wallsend G pit and continuing the sinking of the H pit, with a view to restart the colliery.

Operations were at once commenced to lower the water in the former pit, while arrangements were being made to resume sinking in the latter. A second cornish engine, exactly similar to the original one was erected in the same engine-house, and commenced to work on May 21st, 1894; the new pumps being placed on the wrought-iron box-girder which was provided when the first engine was erected (Fig. 2, Plate V.). In the meantime the water, in the G pit, was being drained at the rate of 1,800 gallons per minute, and the rubbish cleared out. Owing, however, to the uncertain nature of the ground in this shaft, the pumps had to be slung with ropes. These ropes were attached to horse-crabs, and taken through ground-blocks hung from buntons in the pit, and fastened near the bottom of each of the four sets (Figs. 3 and 4, Plate V.). The sinkers also had to be provided with belts and a chain fastened to a secure part of the shaft, in case the rubbish on which they were standing should give way beneath them, as indeed sometimes it did; such then was the method of clearing the road down to the High Main coal-seam, which was reached in May, 1894. To the level of this seam, 672 feet from the surface, the G pit had originally been constructed as an open shaft, some 12½ feet in diameter, and was divided by a wooden brattice into three equal divisions (Fig. 5, Plate V.), one being used for pumping and the other two for drawing coals; the ventilating-furnaces being at the A and B pits, about 1 mile westward. Between the High Main and Bensham coal-seams the brattice was discontinued, and almost within the area of the shaft, three staples about 6 feet in diameter formed the communication not only between these two seams, but had been sunk a distance of 60 feet lower in order to win and utilize as water-standage a tract of coal lying to the south beyond a dip-trouble of 54 feet (Fig. 6, Plate VI.).

During this period the H pit sinking had been begun, but after the shaft was carried down a few feet below the top girders, feeders of water were encountered in such quantities as to suggest the advisability of putting down a borehole to the High Main coal-seam; a drift was accordingly driven from the G pit to a point immediately below the new shaft into which (on the completion of the borehole) the water was conducted, the hole being kept clear in the usual way by inserting a chain. The sinking of the pit was then proceeded with until the High Main coal-seam was reached, at 672 feet from the surface, in February, 1895. Slightly below this point a second set of girders had to be placed on which the No. 2 sets of pumps were to stand. These girders (one being 26 feet and the other 22 feet in length) were, like the higher ones, built of iron of box form, and weighed 19 tons and 15 tons respectively.

Unfortunately, however, the ground immediately below the High Main coal-seam (at the very point where they had to be placed, and a large water-lodge excavated) proved to be of a very soft nature, so soft, indeed, that the writer has seen, on more than one occasion, a spike driven with ease a distance of 4 feet into the solid bottom of the pit. This stratum of soft blue stone extended for a distance of 72 feet below the seam, and it was not till then that a bed could be found sufficiently good to commence walling from. It will be readily understood that no reliance could be placed on rock, if such one might term it, of this nature to resist any considerable superincumbent weight, estimated, with the pumps when full of water—and any shock that reasonably might be anticipated through the admission of air—to be not less than 150 tons; consequently, this portion of the shaft had to be lined with walling 2 feet in thickness, or just double that used under ordinary circumstances. The extra thickness of masonry, of course, required an extra foot of stone to be cut out all round the shaft, beyond the backing-deals, as the walling advanced; and, to add to the trouble and labour while this work was being carried out, the soft stone began to run from beneath the seam above, till, for two-thirds round the pit, the space behind the backing-deals measured no less than 7 feet in the widest part. It was subsequently ascertained that the run had taken place at a slip or back. Heavy timber or baulks had to be temporarily set across the pit, as well as double cribbing resorted to, in order to keep the unwalled portion safe. It might be here noted, that the space left by the stone falling from the sides was filled up with concrete behind the walling, in the proportion of 1 of cement to 5 of sand and stones, the stones being broken to a size such as would pass through a screen having a mesh 2 inches square. When the masonry had reached the level at which the girders had to be placed, it was found impossible to lower them into their seats on account of the numerous baulks of timber reaching from one side of the shaft to the other. To admit of their removal, it was at once evident that the only course to pursue was to complete the walling and make all secure up to the good stone 9 feet above the High Main coal-seam. In carrying this out, provision had to be made for the insertion of either ends of the girders into the sides of the shaft, so as to obviate the necessity of having to break or interfere with the construction of this masonry; and to meet this the following method was adopted. Elliptical arches were formed of ordinary hard bricks at each point where the ends of the girders had to be let into the sides of the shaft, except the lower portion, which had to take the weight; and here specially hard burnt bricks of superior quality were

used, their crushing resistance being equal to 100 tons per square foot. Within these arches a combination of brick and timber stoppings was built, and chocks adjusted between them and the stone-face to prevent further run of stone. Four of these arches were turned for the girders, and another, of much larger dimensions, for the water-lodge room immediately above.

Considering the weight to be resisted it was thought highly advisable that it should be spread over as large an area as possible, and cast-iron bed-plates or shoes were provided on which either ends of the girders rested, and thus reduced the weight on each square foot of brick and concrete work. After being carefully adjusted in their proper places, the remaining space within and behind the arch-rings was filled with concrete of the same consistency as that mentioned above and faced with brickwork flush with the sides of the shaft.

The water-lodge room was then dealt with in a similar way, its dimensions being $11\frac{1}{4}$ feet wide by 22 feet long by 17 feet high, and to ensure its being water-tight it was lined out with brickwork and cement, both floor, sides, and part of the roof.

At this stage, the sinking in the G pit (a little below the High Main coal-seam) had to be suspended, on account of the column of water on the pumps, which had become too great. All hands were therefore taken to the H pit to perform the work of setting the two second sets of pumps of the permanent engines. These were completed and set to work on November 11th, 1895.

The pumps in the G pit were then taken off down to the High Main coal-seam, and the sinking was again resumed, or rather the removal of the stone existing between the staples within the area of the pit.

There being now no borehole in the H pit, it was deemed advisable to avoid any pressure of water against the working-bottom of this shaft, and, with this end in view, the water in the G pit was regularly kept 12 feet in advance, till the H pit had reached a depth of 72 feet below the Bensham coal-seam, or 948 feet from the surface, and slightly below the under-level drifts leading from the low tract of coal previously referred to as lying to the south beyond the dip-trouble of 54 feet.

At this depth the H pit is stopped. Wrought-iron girders (Figs. 7 and 8, Plate V.) were again employed (in case the pit should ever be required to be sunk further), and the third or low sets of pumps placed thereon which deliver at the High Main level (Figs. 9 and 10, Plate VI.).

During the time occupied with this work in the H pit, attention was

directed towards the clearing of the old under-level drifts from the G pit side, and the driving of a new one to form a connexion with the H pit; on these being lined with brickwork throughout and finished, a dam was constructed at the H pit end and furnished with a sluice-valve 2 feet in diameter. From this valve, a rod is taken up to the Bensham coal-seam some 72 feet above, so that the water being delivered at the shaft can be controlled at will, even should it be high in the pit-bottom.

The whole of the feeders of water being thus delivered at the main-engine pumps in the H pit, those of the G pit being now no longer of use were taken out, and the engines dispensed with. A bed was then formed at the same level as the H pit-bottom, and cast-iron tubbing with internal webs (to admit of each segment being bolted together both in the horizontal as well as the vertical joints) was put in up to the Bensham coal-seam, and wedged in the usual way. The reason why fastening the segments by means of bolts was resorted to, was on account of the tubbing being only carried up to the flat-sheets of the Bensham landing, and there being nothing immediately above it to wedge against: or, in other words, it is open-top tubbing, and since the G pit is connected with the old under-level drifts as before stated, this tubbing prevents the water from flowing down to the Low Main coal-seam, until it has risen over 54 feet above the standage-level. All the water being taken off this pit, the further sinking in solid ground was carried on, practically dry, to the Low Main coal-seam, which was reached on December 27th, 1897, and a communication made into these workings which had been, for some years, carried on from the Hebburn pits only. The pillars which had all along been left, on account of the water above, are now available to be worked off.

It might be here mentioned that the idea, entertained by so many, of an underground lake existing in the High Main and Bensham coal-seams proved to be a complete fallacy, since in passing the former seam in the old shaft the floor of the very shaft-sidings was found to be squeezed up to the roof in a compact mass, and in the latter the roof had fallen close.

A heapstead, with spreading and picking or cleaning-belts and shaking-screens on the latest principle, has been erected.

Shipping-gears of a unique description have also been constructed, and are described in Mr. Moncrieff's descriptive notes.*

The time taken to execute the work thus far may seem at first sight somewhat lengthy, but when we take into account the large feeders of

* *Trans. Fed. Inst.*, vol. xv., page 75.

water to contend with, the many unforeseen difficulties to be overcome in opening the old shaft, and the extraordinary precautions to be adopted, we can realize what has to be faced in a work of this description.

Mr. J. B. Simpson (Newcastle-upon-Tyne) said that the thanks of the members were due to Mr. T. E. Forster and Mr. H. Ayton for their papers describing one of the most interesting collieries in the world. Wallsend colliery had the reputation of being not only the most difficult of collieries to manage in the early days, but it also produced the very best coal in the world; and he believed that it was then the most commercially successful. It had one great advantage in its favour—that it was managed by Mr. John Buddle, jun., who was probably the leading mining engineer, in his time at any rate, and, he believed, the first who opened the sunless caves of their coal-mines to the light of science. He was the first man who applied scientifically all that he knew towards the regulation of mines. The notes written by Mr. Forster comprised a complete *résumé* of what took place at that early period.

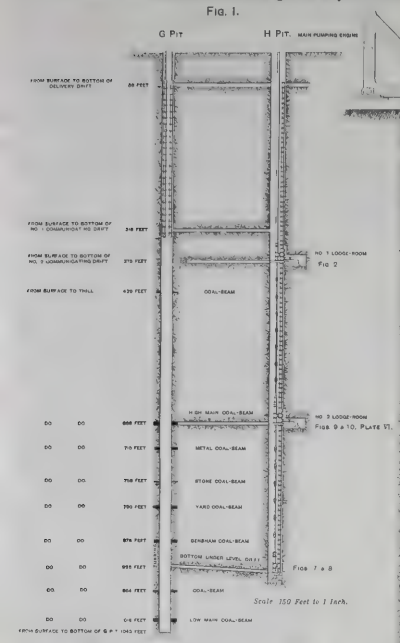
He (Mr. Simpson) happened to have some of Mr. Buddle's manuscripts and notebooks of his Wallsend visits. They were most painstaking, and, he thought, an example, especially to young men, for the minute way in which he described the daily working of the mine. Everything that took place he had noted at great length. No doubt Mr. Buddle carried on the Wallsend colliery very successfully, but he laboured under very great disadvantages, and Mr. Forster had referred especially to the difficulties that he had encountered in respect to the ventilation of the mine. The quantity of air, of course, was very small—only 4,000 or 5,000 cubic feet per minute—and creep frequently took place. The pillars of coal were left perhaps not containing 50 per cent., as they had adopted the same system in the deep mines as they had in the outcrop mines. The 50 per cent.—and in fact it was sometimes only 30 per cent.—was not adequate to keep up the surface; creeps were frequent, and a creep often had the effect of altering and reversing the current of air, so that one day the upcast shaft was an upcast, and the next day it was a downcast. On one occasion, about the year 1815, there was a very severe creep, and they found the current of air reversed. All kinds of means were tried to get it right and steam was put down without effect; ultimately they lowered heated boiler-plates into the upcast shaft, and that had the desired effect. Mr. Buddle always

ng of Wallsend Colliery."

FIG. 4

To illustrate Mr. H. Ayton's Paper on "The Re-opening of Wallsend Colliery."

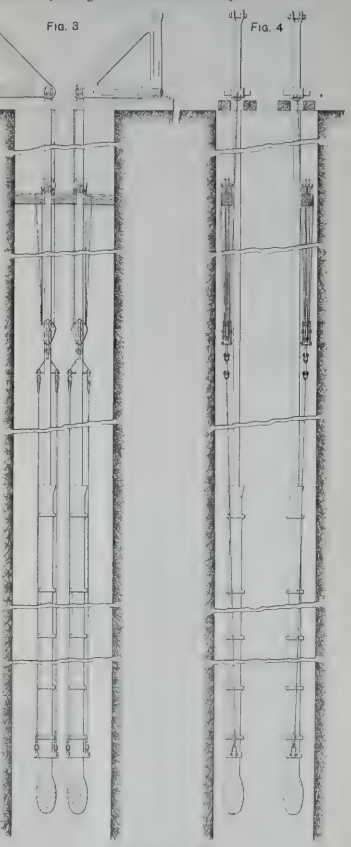
Fig. 1.



Scale 150 Feet to 1 Inch.

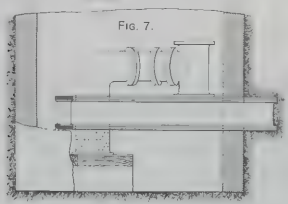
Fig. 3

Fig. 4



Scale, 10 Feet to 1 Inch

Fig. 7.



Elevation on line A B, Fig. 8

Scale, 6 Feet to 1 Inch

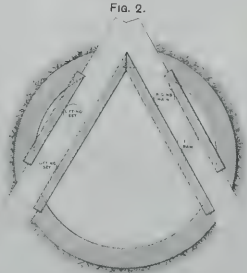
Fig. 8.

Plan of H Pit, Shaft bottom

Fig. 5

Scale, 8 Feet to 1 Inch.

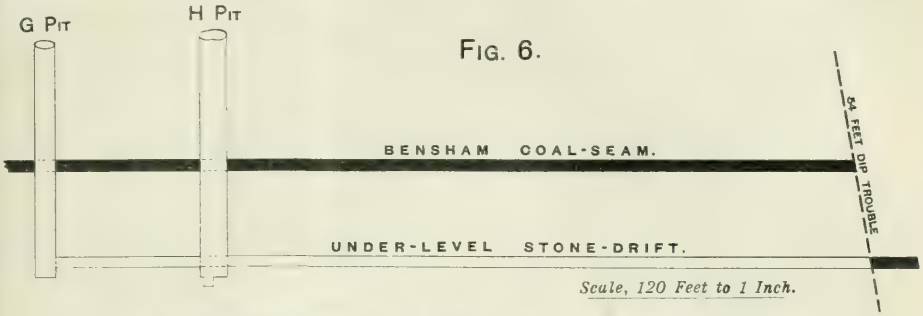
Fig. 2.



Plan of Iron Girders at No 1 Lodge Room

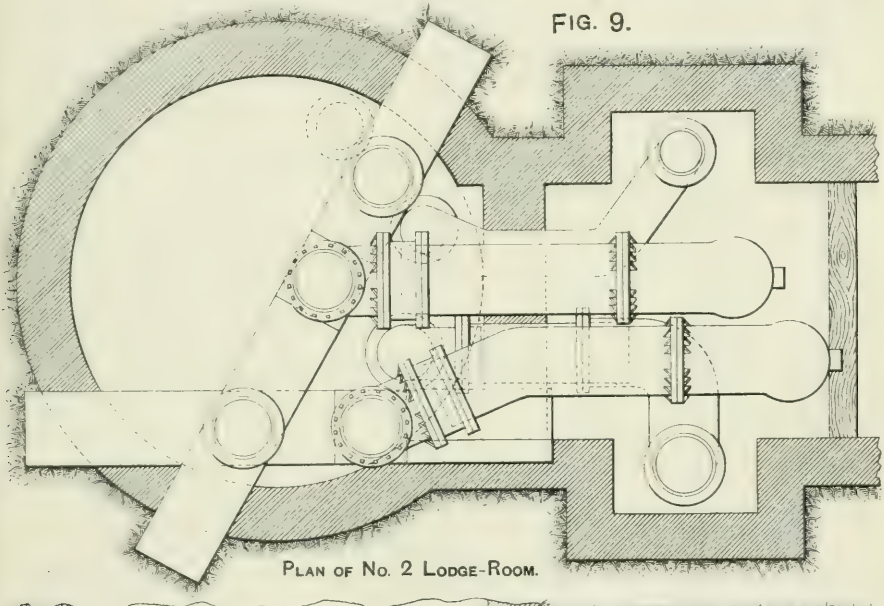
To illustrate Mr. H. Ayton's Paper on "The Re-opening of Wallsend Colliery."

FIG. 6.



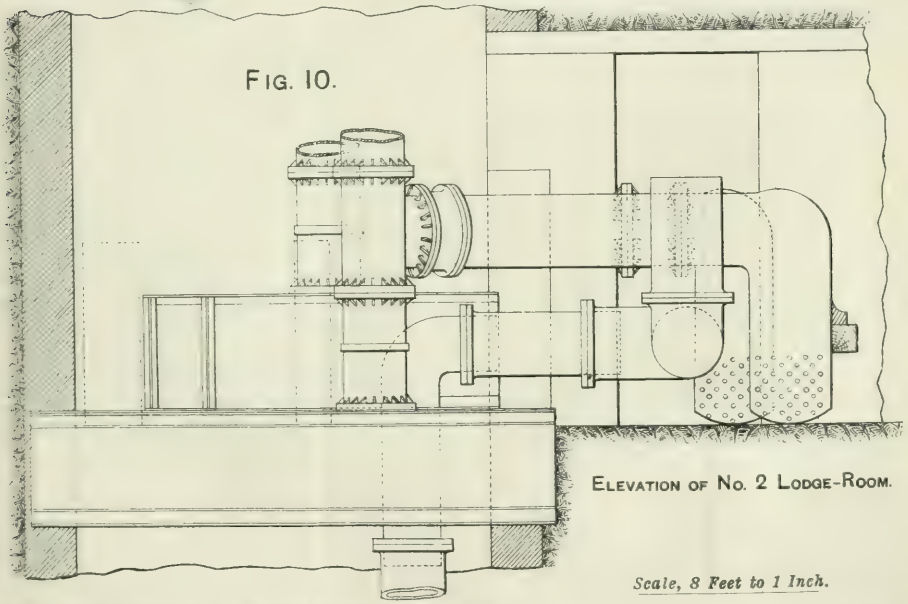
Scale, 120 Feet to 1 Inch.

FIG. 9.



PLAN OF No. 2 LODGE-ROOM.

FIG. 10.



ELEVATION OF No. 2 LODGE-ROOM.

Scale, 8 Feet to 1 Inch.

got to the end of his difficulties, and there was a note next day that they had "got the pit to work." That seemed always to be the great point—to get the pit to work.

He (Mr. Simpson) was connected with the colliery in 1867, and he was extremely glad to find that some of the proposals which he made 30 years ago for the draining of the mine had now been carried out successfully. It was always thought, as Mr. Ayton had said, that there was an underground lake in the Tyne basin. At Hebburn colliery, which he had drained, it was expected that when they got to the High Main coal-seam they would have very great difficulty with the water-feeders. But the difficulties were nothing like what they had anticipated, as they lowered the water at the rate of 2 feet a day. A similar occurrence had taken place at Wallsend, and the High Main coal-seam was passed through in a very short time, showing that a heavy creep had taken place in the workings, that there were no openings and no cavities into which the water could enter, and that the feeder was almost the only thing against which they had to contend.

They must congratulate Mr. Ayton, and also Mr. G. B. Forster, who was managing director of the present company, on the carrying out of the drainage of the Tyne basin. There was no doubt that it would continue to afford coal for a great many centuries, and although the 6 feet seam of Wallsend coal, which was the synonym for all good coal, had disappeared, yet they hoped that there was still good coal left which would warm the shins of the present generation.

Mr. H. C. Embleton (Leeds) said his recollection of Wallsend would not carry him back as far as Mr. Simpson had stated, but probably he could remember it 30 or 35 years ago, when his uncle (Mr. J. Easton) was connected with the colliery. He would like to ask Mr. Ayton whether, if he had another colliery to open out, he would prefer to do it by opening out an old shaft or by sinking a new shaft from the surface ?

Mr. M. H. Mills (Mansfield) said that, as a south-country member, he would not like this opportunity to pass without congratulating his north-country brethren on the carrying out of so important a work. It was an accomplishment which Prof. Louis would no doubt note with pleasure in view of his apprehensions as to the competition of foreign engineers. Mr. G. B. Forster and Mr. H. Ayton were to be congratulated on being able to carry out such difficult work, and after they had had an opportunity of reading the papers carefully through they would no doubt learn a great deal about the engineering work.

Mr. A. L. Steavenson said that the members would all agree that it had been a very stiff job very well done, and he did not believe that either Continental or American engineers could have done it any better.

Mr. Ayton said that there were no questions to which it was necessary to reply except that of Mr. Embleton, and he would have no hesitation in saying that he would rather sink a new pit than open out an old one.

The President moved a vote of thanks, which was cordially accorded to Messrs. Forster and Ayton for their papers.

Mr. H. C. Peake moved, and Mr. M. H. Mills seconded, a resolution that a very hearty vote of thanks be accorded to the committee of the North of England Institute of Mining and Mechanical Engineers for the arrangements which they had made for this meeting, and also to the owners of works to be visited, and to the River Tyne Commissioners for the use of their steamer.

The resolution was agreed to.

Mr. George May moved a vote of thanks to the President for his services in the chair, and this being agreed to, the meeting terminated.

The following notes record some of the features of interest seen by visitors to works and collieries, which were, by kind permission of the owners, open for inspection during the course of the meeting on February 22nd, 23rd, and 24th, 1898:—

TELEGRAPH AND TELEPHONE DEPARTMENTS, GENERAL POST OFFICE.

The members visited the superintending engineer's office and saw the district wire-diagrams, which gave some conception of the high development of the telegraph and telephone services in Northumberland and Durham.

They visited the telegraph instrument-room, where among the noteworthy objects were the translators for the London-Aberdeen or English-Scotch service, Wheatstone fast-speed automatic apparatus (600 words per minute), concentrators, test-box, and time apparatus.

In addition the members inspected the telephone message-room (where telegrams are received from telephone-subscribers all over the two counties), the telephone local exchange, the telephone trunk exchange, the battery-room, electric light transformer-room, the engine-house, and the telegraph store-house.

WALLSEND COLLIERY.

The pits are two in number, namely, the G and H. The former or upcast-pit, 12 feet 6 inches in diameter, is the original shaft from which coals were drawn, up to the year 1854, when it became drowned out. The shaft was then sunk as far as the High Main coal-seam, and from there to a point about 60 feet below the Bensham coal-seam, three small staples were put down within the area of the shaft. The rock left between these staples has now been removed to this level, and the shaft sunk to the Low Main or Hutton coal-seam.

The H or downcast and pumping-pit is 17 feet 6 inches in diameter, and has been sunk from a point 378 feet from the surface (it being for some years used only to keep the water at a certain level) to 60 feet below the Bensham coal-seam.

These shafts have passed through the following coal-seams:—

Coal-seams.	Thickness. Ft.	Ins.	Depth. Feet.
High Main	6	6	672
Metal	3	0	714
Yard	3	3	816
Bensham	4	9	876
Low Main (yet to sink to, in G pit only) ...	5	0	1,014

The winding-engine at the G Pit has two cylinders, each 38 inches in diameter by 5 feet stroke; and the drum is 18 feet in diameter and 7 feet wide.

There are two spreading-belts, 5 feet wide by 12 feet long, travelling 12½ feet per minute, and delivering on to two main picking-belts, 5 feet wide by 71 feet long, travelling 50 feet per minute. These in their turn deliver their load on to two ordinary jigging-screens.

The Walker fan is 16 feet in diameter, and capable of giving 200,000 cubic feet of air per minute, with a 4 inches water-gauge, at about 220 revolutions per minute. It is driven by seven ropes on to the fan-pulley, 6 feet in diameter, from the engine-pulley, 15 feet in diameter. The engine has two cylinders, 18 inches in diameter by 3 feet 6 inches stroke, fitted with a Proell governor and expansion-valves. Each cylinder is capable of driving the fan at full speed, with a steam-pressure of 90 pounds per square inch.

The two cornish engines by Messrs. Harvey & Co., Cornwall, 100 inches by 11 feet stroke, are both capable of raising 2,000 gallons per minute from a depth of 940 feet, with steam at a pressure of 50 pounds per square inch. The pumps consist of three sets, viz.:—

New engine—

Low set, forcing 264 feet, with 26 inches ram, and 11 feet stroke.
Middle set ,, 295 ,, 26 ,, 11 ,,
Top set ,, 324 ,, 26 ,, 11 ,,

Old engine—

Low set, 2 lifts, side by side 264 feet, with 19½ inches buckets, and 11 feet stroke.
Middle set, forcing 294 ,, 26 ,, ram ,, 11 ,,
Top set ,, 324 ,, 26 ,, ,, ,, 11 ,,

HYLTON WINNING.

Two drawing-shafts, 20 feet in diameter, and an independent upcast shaft, 15 feet in diameter, are being sunk for the purpose of working the Maudlin and Hutton coal-seams.

The Maudlin coal-seam is expected to be met with at a depth of 1,440 feet, and the Hutton coal-seam at 1,560 feet, but as a considerable area of the royalty lies on the dip-side of a large fault of an estimated throw of 360 feet, one or more of the shafts will eventually have to be sunk to a depth of probably 1,920 feet.

The winding will be done by two horizontal engines, each with two cylinders, 34 inches in diameter and 72 inches stroke; the steam-pres-

sure will be 120 lbs. per square inch, and provision will be made for connecting the engines to an independent condensing-plant; plane-drums will be used, 20 feet in diameter.

The headgear will be of steel lattice-girders raised upon a substantial heapstead built of brick and cement, and the winding-pulleys will be 20 feet in diameter, made (in Germany) in segments, with flat steel spokes.

The cages will run in wire-rope guides, and will each carry eight 10 cwts. tubs on two decks: the decks being loaded and discharged at separate levels. It is intended to counterbalance the ropes by means of continuous ropes placed under the cages.

The screening apparatus will be common to both drawing-shafts, and will project from the north side of the heapstead.

Sinking was commenced in the middle of 1897, and two of the shafts have now reached the depth of 630 feet.

WHITBURN COLLIERY.

There was employed at one time during the sinking of the shafts, the following pumping-plant:—Three engines each with two cylinders, 48, 44, and 26 inches respectively in diameter. There were two sets of pumps 30 inches in diameter by 6 feet stroke; and three sets 20 inches in diameter by 5 feet stroke. The largest quantity of water pumped was 12,000 gallons per minute, and this is the greatest quantity of water pumped at any winning in the North of England. Ultimately the volume of water became so great that the sinking was stopped.

The Kind-Chaudron system of sinking was then commenced, two pits were eventually sunk through the water-bearing strata, and the water was tubbed off by this process.

There are two winding-engines, each having two cylinders, 48 inches in diameter by 6 feet stroke. The winding-engines are capable of drawing about 4,000 tons of coal per day.

On the surface, there are two hauling-engines, each having two cylinders 24 inches in diameter by 4 feet stroke, and fitted with two drums working on the main-and-tail rope system (one is now temporarily used for winding). There is another engine, with two cylinders 20 inches in diameter, driving an endless-rope haulage. There are 18 small hauling-engines in the mine, driven by compressed air, and working secondary-haulage systems.

For the purpose of working the secondary hauling and pumping-engines underground, there are two air-compressing plants: one with two

steam-cylinders, 30 inches in diameter, and air-cylinders 30 inches in diameter by 5 feet stroke; while the other has two steam-cylinders, 40 inches in diameter, and two air-cylinders, 38 inches in diameter by 6 feet stroke.

The colliery is ventilated by means of a Walker fan, 24 feet in diameter and 8 feet wide, driven by a compound horizontal engine, with cylinders 22 and 38 inches in diameter by 4 feet stroke. With the engine running at 41 revolutions per minute, and the fan at 91 revolutions per minute, 256,000 cubic feet of air are produced at a water-gauge of 3 inches. The useful effect is 70·57 and 58·7 per cent. respectively on the water-gauges taken at the fan-inlet or at the surface.

There are 15 double-flued Lancashire boilers, 2 marine type of boilers, and 5 cylindrical boilers.

There are four main jigging-screens, each capable of making four descriptions of coal (best, nuts, peas and duff). There is also a nut-coal jigging-screen. There are six main steel-belts, each about 70 feet long by $5\frac{1}{4}$ feet wide: one cross-belt for splint-coal, two cross-belts for small-coal, and two cross-belts for nut-coal.

Lamp-rooms are being erected for oiling, cleaning, examining, repairing and storing upwards of 2,500 safety-lamps.

The whole of the surface-erections and buildings are lighted by electricity, the plant consisting of:—A Robey engine with a cylinder $19\frac{1}{2}$ inches in diameter by 40 inches stroke, fitted with automatic expansion-gear, and working at 80 revolutions per minute. The No. 1 dynamo will supply 400 lights, and the No. 2 dynamo will supply 1,000 lights. It is proposed to carry cables down the shaft and light the shaft-bottoms, sidings, stables, etc.

MARSDEN LIMESTONE-QUARRIES AND LIMEWORKS.

Limestone is extensively worked from these quarries for use in chemical works and ironworks, and also for building purposes. Stone-dressing machinery, saws, etc., are working in the quarries.

MESSRS. ERNEST SCOTT & MOUNTAIN, LIMITED, CLOSE WORKS, NEWCASTLE-UPON-TYNE.

The electrical plant and other machinery in course of construction, and on view during the visit, comprised:—A set of three-throw mining pumps (high lift) capable of delivering 500 gallons per minute against

a head of 750 feet; a set of three-throw mining pumps capable of delivering 1,000 gallons per minute against a head of 300 feet; a set of 10 inches by 12 inches pumps capable of delivering 500 gallons against a head of 150 feet; a set of three-throw mining pumps (low lift) capable of delivering 200 gallons per minute against a head of 250 feet; and 4 sets of centrifugal pumps and engines combined. Two 200 units generators, and three 80 horsepower motors for driving pumping machinery.

Two 90 units generators for driving electric haulage plant; and an endless-rope electric-haulage plant with 40 horsepower motor, driven through worm-gearing.

Electric coal-cutting machine, fitted with disc of suitable diameter to cut 4½ feet deep, driven by motor of 30 horsepower.

An enclosed compound engine of self-lubricating type, coupled direct to Tyne dynamo with drum-bar armature, and an output of 44,000 watts.

An electric locomotive fitted with motor of 25 horsepower and suitable for 2 feet gauge; designed for use in mines or for contractors' use underground.

Two ventilating fans driven by electric motors, capable of delivering 10,000 cubic feet of air per minute at a water-gauge of 4 inches.

A number of dynamos of various types, electric motors, high-speed steam engines, and other specialities were seen in course of construction.

"NEWCASTLE CHRONICLE."

The members visited the printing works of the *Newcastle Chronicle*, and were shown the various details of the production of the special edition of the *Evening Chronicle*, including the operating of the linotype machines, and printing, folding, despatching, etc., of the paper.

MESSRS. GEORGE DAVIDSON & COMPANY. TEAMS GLASS-WORKS.

The members were shown the various processes employed in the manufacture of pressed-glass goods, including the preparation, mixing and melting of the materials. The processes of moulding and annealing were also shown, together with the packing, and despatching of the goods to the various markets.

MESSRS. DIXON & CORBITT AND R. S. NEWALL & COMPANY, LIMITED, TEAMS ROPE-WORKS.

The members were shown the various processes employed in the manufacture of wire and hemp ropes; and the various kinds used for hauling, winding and other purposes, and for running and fixed systems of rope-tramways.

"NEWCASTLE DAILY NEWS."

The members visited the offices of the *Daily News* and saw the process of producing an evening newspaper, including the printing, folding, and despatching of the third edition.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, APRIL 2ND, 1898.

MR. T. W. BENSON, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on March 19th and that day, and of the Council of The Federated Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Mr. ROBERT LUNAN WEIGHTON, M.A., Professor of Engineering and Naval Architecture, Durham College of Science, Newcastle-upon-Tyne.

MEMBERS—

Mr. WILLIAM MORTEN BREWER, Mining Engineer and Geologist, c/o Mr. George T. Chester, 526, Delaware Avenue, Buffalo, New York.

Mr. JOHN SAMUEL BROWNING, Mining Surveyor and Engineer, Nelson, New Zealand.

Mr. JOHN HUBERT DEWHURST, Mining Engineer, Grove House, Walton-le-Dale, Preston.

Mr. JOHN BUCKMAN ESUMAN-GWIRA, Civil and Mining Engineer, Cape Coast Castle, West Africa.

Mr. ARTHUR HASELDEN, Mining Engineer, Linares, Spain.

Mr. JAMES O. HUDSON, Inspector of Mines, Menzies, Western Australia.

Mr. GEORGE THOMAS KENNEDY, M.A., B.A.Sc., D.Sc., F.G.S., Professor of Chemistry, Geology and Mining, King's College, Windsor (Hants County), Nova Scotia.

Mr. GEORGE HENRY MATTHEWS, Mining Engineer, 48, Tynte Street, North Adelaide, South Australia.

Mr. FREDERICK NEWBERY, Mining Engineer, P.O. Box 1,647, Johannesburg, Transvaal.

Mr. ARCHIBALD LAURENCE WILSON, Mine and Mill Manager, Mining Engineer, Ravenswood, Queensland, Australia.

ASSOCIATE MEMBERS—

Mr. MAX. BAKER, Editor of *Arms and Explosives*, Effingham House, Arundel Street, Strand, London, W.C.

Mr. H. P. BELL, Victoria, British Columbia.

Mr. JOHN ROBERT CHAFFEY, F.R.G.S. (Aust.), 338, Collins Street, Melbourne, Australia.

Sir GEORGE ELLIOT, Bart., 16, Great George Street, Westminster, London, S.W.

Mr. J. STEPHEN JEANS, Secretary, British Iron Trade Association, 222-225, Strand, London, W.C.

Mr. WILLIAM KIRKBY, Front Street, Bedlington, R.S.O., Northumberland.

Mr. HERBERT LLOYD, Engineering Offices, Middelburg, Transvaal, S.A.R.

Mr. WALTER FRANCIS ROBINSON, Greymouth, New Zealand.

Mr. RALPH WILLIAMS, Geelong Gold-mines, Gwanda, Matabeleland, South Africa.

Mr. THOMAS J. WILLIAMS, Moyston, Victoria, Australia.

ASSOCIATE—

Mr. WILLIAM WAINWRIGHT, Deputy, Heworth Colliery, Felling, R.S.O., Co. Durham.

STUDENTS—

Mr. HAROLD CRESSWELL BAYLDON, Mining Student, Rialton, Higher Erith Road, Torquay.

Mr. JOHN WALTON ROBINSON, Jun., Mining Student, 6, Gladstone Terrace, Gateshead-upon-Tyne.

DISCUSSION OF MR. W. E. GARFORTH'S "SUGGESTED RULES FOR THE RECOVERY OF COAL-MINES AFTER EXPLOSIONS."*

Mr. J. T. ROBSON (H.M. Inspector of Mines) wrote that, although the rules suggested by Mr. Garforth included several precautionary measures which were now taken at many collieries as well as many methods of procedure which had been carried out after explosions during the last 20 years, they were none the less worthy of most careful discussion and consideration. Personally, he had experienced the want of the information which would have been available had Rule 12 been observed, and this occurred at a time when the manager and, with one or two exceptions, all his subordinates had been either injured or killed by a large explosion. On some occasions he had known nearly every official of the colliery to have been exhausted from fatigue or from after-damp at the end of 8 to 12 hours, and the work had then to be continued, so far as direction and supervision were concerned, by strangers. Of course the reason for this

* *Trans. Fed. Inst.*, vol. xiv., page 495.

was clear—the anxiety on the part of every official to try and save life; but it would generally be wiser if some of them desisted from active underground work after 1 or 2 hours, so as to be able to replace others when they became worn out.

On at least two occasions when he had arrived at a colliery after a big explosion, he had found considerable laxity in discipline as to giving directions, issuing safety-lamps, and recording the names of persons who were descending in cage-loads, ostensibly to take part in the explorations and recovery of the bodies. Most of the men thus descending did assist, but others went a very short distance, ascended on the first opportunity, and did not return.

With reference to Rule 48, he suggested that the recovery of the dead should be deferred until all hope of saving life was abandoned; and that, unless there was imminent danger of a fall at any spot where a body was found, every body found should be left undisturbed until H.M. inspector of mines or an assistant, and an official of the colliery, had examined the body and the surroundings, and made their notes. This should also apply to everything, except what must of necessity be removed for the passage of the explorers.

The following paper on "Secondary Haulage: Cost of Putting and Driving," by Messrs. T. E. Forster and F. R. Simpson, was read :—

SECONDARY HAULAGE: COST OF PUTTING AND DRIVING.

By T. E. FORSTER and F. R. SIMPSON.

Since Mr. W. Galloway introduced the subject of secondary haulage to general notice in his valuable paper, read in 1896, several discussions have taken place with reference to it.*

Feeling interested in the matter, the writers propose to put forward some figures which they have obtained with a view to showing the cost of secondary haulage by horses and ponies as it is practised in the North of England coal-field. Before doing so, however, they wish to observe that the figures have been got together merely as a statement of facts, and not with a view to proving that this or that particular system is superior to any other. So much depends, in their opinion, on the precise conditions under which secondary haulage has to be performed, that it is impossible to lay down any general law as to which system may be most economical, and it is therefore equally impossible to compare one system with another except under exactly similar conditions. Even in the latter case, the result is only to prove that one of the systems compared is more suitable for the conditions existing at the scene of the experiment.

Judging from the discussions in which the cost of secondary haulage in South Wales has been compared with the cost of the same in the North of England, there seems to be some little misapprehension in the matter. It appears to have been assumed that the North of England system described as "putting" consists of the haulage of single tubs from the face to the engine-plane by single animals. This, however, it may be explained, for the benefit of those unacquainted with the district, is not altogether the case. The system which would be better described as "putting and driving," consists of "putting" by ponies from the face to certain collecting-points, and of "driving" thence to the engine-planes, in the latter case the tubs being drawn in short trains by a horse or large pony.

* *Trans. Fed. Inst.*, vol. xii., page 257; vol. xiii., page 117; and vol. xiv., page 102.

It must be understood that this system is usually applied to workings where the conditions are favourable, the gradients being light, as is generally the case in this district. Under exceptional circumstances, such as heavy gradients or isolated districts approached by long roads from the engine-planes, mechanical secondary haulage is of course more beneficial, and appears to be increasing in favour.

The figures given in the tables have been taken from twelve different pits working under what may be called fairly average conditions, with a fair proportion of thick and thin seams, as well as of bord-and-pillar and longwall workings.

In working out the costs, the following items have been included:— (1) Maintenance, comprising cost of feeding, attendance, shoeing, veterinary surgeon, and harness; (2) wages paid to putters and drivers; and (3) interest and depreciation, being such a sum as will pay interest at 5 per cent. on capital and provide for renewals at the average rate of mortality.

Under the latter head, it is interesting to note the difference in the duration of underground horses and ponies respectively. The average working-life of a horse appears to be only from 5 to 6 years, while that of a pony seems, on the other hand, to be about twice as long. As the greater proportion of the haulage is generally performed by the last-named animal, it follows that the cost under this head is less than where horses are exclusively employed.

TABLE I.—PUTTING.

Colliery.	Capacity of Tub.	No. of Ponies.	Average Distance.	Tons per Day per Pony.	Cost per Ton.				System of Working.
					Wages.	Maintenance.	Interest and Depreciation.	Total.	
	Cwts.		Yards.	Tons.	d.	d.	d.	d.	
1	7	42	160	19·0	1·927	0·675	0·113	2·715	Bord-and-pillar and longwall.
2	7¼	31	200	27·0	1·745	0·486	0·064	2·295	Longwall.
3	8	28	160	23·0	1·809	0·568	0·076	2·453	,,
4	8¾	25	194	30·3	1·405	0·431	0·056	1·892	,,
5	8¾	26	214	22·1	1·560	0·590	0·077	2·227	,,
6	9	19	198	25·3	1·822	0·534	0·064	2·420	,,
7	10¼	37	167	21·1	2·041	0·541	0·098	2·680	Bord-and-pillar.
8	10¾	21	157	31·1	1·454	0·480	0·052	1·986	Longwall.
9	12¼	34	145	29·4	1·264	0·519	0·077	1·860	Bord-and-pillar.
10	12¾	33	251	34·5	1·500	0·431	0·047	1·978	,,
11	13	27	164	33·5	1·414	0·405	0·054	1·873	Bord-and-pillar and longwall.
12	13	13	158	34·8	1·340	0·431	0·046	1·817	Bord-and-pillar.
Averages	—	—	180	27·0	1·584	0·500	0·068	2·152	

TABLE II.—DRIVING.

Colliery.	Capacity of Tub.	No. of Animals.			Average Distance.	Tons per Day per Animal.	Cost per Ton.				System of Working.
		Horses.	Ponies.	Total.			Wages.	Maintenance.	Depreciation and Interest	Total.	
	Cwts.				Yards.	Tons.	d.	d.	d.	d.	
1	7	17	39	56	412	19·0	0·747	0·920	0·109	1·776	Bord-and-pillar and longwall.
2	7¼	2	21	23	609	36·2	0·424	0·449	0·065	0·938	Longwall.
3	8	13	12	25	700	25·7	0·642	0 723	0·111	1·476	,,
4	8½	3	14	17	478	44·6	0·346	0.376	0·055	0·777	,,
5	8½	5	17	22	283	26·1	0·560	0·651	0·095	1·306	,,
6	9	4	10	14	499	34·4	0·448	0·552	0·086	1·086	,,
7	10¼	12	3	15	252	46·6	0·445	0·461	0·063	0·969	Bord-and-pillar and longwall.
8	10¾	—	25	25	371	26·2	0·581	0·749	0·099	1·429	Longwall.
9	12¼	—	32	32	313	31·2	0·452	0·488	0·072	1·012	Bord-and-pillar.
10	12¾	23	9	32	420	35·6	0·424	0·618	0·091	1·133	,,
11	13	—	37	37	448	24·4	0·776	0·745	0·106	1·627	Bord-and-pillar and longwall.
12	13	—	9	9	295	50·0	0·294	0·390	0·051	0·735	Bord-and-pillar.
Avs.	—	—	—	—	423	30·0	0·531	0·615	0·087	1·233	

TABLE III.—PUTTING AND DRIVING COMBINED.

Colliery.	Capacity of Tub.	No. of Animals.			Average Distance.	Tons per Day per Animal.	Cost per Ton.				System of Working.
		Horses.	Ponies.	Total.			Wages.	Maintenance.	Depreciation and Interest	Total.	
	Cwts.				Yards.	Tons.	d.	d.	d.	d.	
1	7	17	81	98	572	9·5	2·674	1·595	0·222	4·491	Bord-and-pillar and longwall.
2	7¼	2	52	54	809	15·4	2·169	0·935	0·129	3·233	Longwall.
3	8	13	40	53	860	12·1	2·451	1·291	0·187	3·929	,,
4	8½	3	39	42	672	18·0	1·751	0·807	0·111	2·669	,,
5	8½	5	43	48	497	12·0	2·120	1·241	0·172	3·533	,,
6	9	4	29	33	697	14·6	2·270	1·086	0·150	3·506	,,
7	10¼	12	40	52	419	14·7	2·486	1·002	0·161	3·649	Bord-and-pillar and longwall.
8	10¾	—	46	46	528	14·2	2·035	1·229	0·151	3·415	Longwall.
9	12¼	—	66	66	458	15·1	1·716	1·007	0·149	2·872	Bord-and-pillar.
10	12¾	23	42	65	671	17·5	1·924	1·049	0·138	3·111	,,
11	13	—	64	64	612	14·1	2·190	1·150	0·160	3·500	Bord-and-pillar and longwall.
12	13	—	22	22	453	20·5	1·634	0·821	0·097	2·552	Bord-and-pillar.
Avs.	—	—	—	—	603	14·1	2·115	1·115	0·155	3·385	

It will be observed from Tables I., II., and III. that the cost per ton does not vary to any great extent, and may be roughly put at about 3¼d. It is no doubt affected to some degree by the size of the tub and the distance travelled; and, with the object of obtaining a fair average,

instances are included of variously sized tubs and different distances. The latter vary in the case of putting from 145 to 251 yards, and of driving from 252 to 700 yards, the average distances being 180 and 420 yards, which may be assumed to be fairly representative.

On referring to the discussion upon Mr. Galloway's paper, it will be found that exception was taken by one of the writers* to the distance of 581 yards being treated by Mr. Galloway under the head of pony-putting, and the tables herewith fully bear this out. Taking the average distance of 603 yards, which is sufficiently near for purposes of comparison in this instance, we find that :—

180 yards is pony-putting at	...	...	2·152d. per ton,
423 ,, driving at	...	...	1·233d. ,,
603 ,, of putting and driving at	...	...	3·385d. ,,

which, compared with 581 yards of entirely pony-putting at 5·572d. per ton, shows a difference of no less than 2·187d. (or 39 per cent.) per ton. If we place this cost against Mr. Galloway's figure of 4·310d. for small engines, we have a balance in favour of putting and driving of 0·925d. (or 21 per cent.) per ton. It is not, however, suggested that this comparison is a fair one ; on the contrary, the writers contend that the circumstances are entirely different, and must not be compared.

The figures have not been worked out, as is often done, to show the cost per ton per mile, because it is thought that this method gives altogether fallacious results. For instance, it does not appear altogether right to state that the cost of labour employed on an engine-plane—1 mile long—will be 4 times as much as that on a plane 440 yards in length. The writers cannot help feeling that such tables as those given in the discussion† are apt to be confusing because all the conditions are not given. This is more especially noticeable in the case of statistics extracted from the Report on Haulage of the Committee of the North of England Institute of Mining and Mechanical Engineers. According to these statistics the endless-rope appears as being very much more costly than the endless-chain, while present experience points in the contrary direction. The reason for the unreliability of these figures may easily be discovered on turning to the report itself and examining the conditions under which the different results were obtained. So far as endless haulage, at any rate, is concerned, it would, the writers think, be interesting to have the report supplemented and brought up to date.

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* *Trans. Fed. Inst.*, vol. xiv., page 102. † *Ibid.*, vol. xii., page 276.

The CHAIRMAN (Mr. T. W. Benson) endorsed the remark in the paper that the working life of pit ponies was about twice that of larger horses, and the latter were very expensive animals for pit use. The paper was confined to the subject of pony-putting, but there was a good deal of hand-putting in this district, and no doubt as thinner coal-seams were worked this method would become even more general: it would, therefore, be interesting to have a comparison made of the respective costs of the two methods.

Prof. H. LOUIS (Durham College of Science) asked whether the item of interest and depreciation included the tubs, and whether the maintenance of tubs, greasing, etc., was included in item No. 1, or whether this item was limited to labour and horseflesh.

Mr. J. H. MERIVALE (Broomhill) referring to the fact that ponies lasted much longer than horses, said that it would be very useful if this could be accounted for. He had also frequently endeavoured to ascertain why horses were more subject to "grease" than ponies, as veterinary surgeons seemed unable to account for it.

Mr. W. C. BLACKETT (Sacriston) thought that "grease" was the result of neglect and ignorance, and the legs of ponies not being so thickly covered with hair did not get so dirty as horses. He asked whether the writers of the paper had any information as to the rate of mortality of horses and ponies in mines.

Mr. A. L. STEAVENSON (Durham) advocated the use of endless-rope haulage, carried as far as possible into the mine. The question of gradient was not referred to in the paper, and this considerably affected the question of haulage-costs. He had endeavoured to measure the power exerted by horses in the Cleveland mines, where the animals were about 17 hands high, and did both putting and driving, and he found that—often for some 50 to 100 feet after the start—this reached the equivalent of 5 nominal horse-power.

Mr. J. C. B. HENDY (Etherley) stated that in his experience of seams as low as 20 and 24 inches thick hand-putting was cheaper than pony-putting. It would add materially to the value of the paper if statistics could be given, say from 12 other collieries, as to the costs of hand-putting. The gradients and the thickness of the seam were also important factors in the question of putting and driving, and information under these heads would be useful.

Mr. T. E. Forster (Newcastle-upon-Tyne), replying to the discussion, said that the writers of the paper would be glad to have information from those familiar with hand-putting, which would enable them to give statistics of this system of haulage. Hand-putting, however, being generally carried on under conditions peculiar to its employment, could not be compared accurately with pony-putting, so far as cost was concerned, each system having its individual merits according to existing circumstances. The gradients at the collieries referred to in the paper were fairly level, and none of them were unsuitable for pony-putting. The instances had been carefully selected so as to give average results under ordinary conditions.

The maintenance of tubs, and greasing, had not been included in the costs as these items were not comprehended in the figures quoted in Mr. Galloway's paper,* in addition to which, it would be practically impossible to separate these costs, which were common both to secondary and primary haulage.

There were differences, though not of great extent, at the various collieries in the average rate of mortality, but probably 9 or 10 years might be taken as the average working life of pit ponies in this district. He thought that the "grease" on horses' legs referred to by Mr. Merivale might, to some extent, be responsible for their shorter working life. "Grease" appeared to be ascribed in some places to the muddy roads of wet pits, and he had known instances where horses were not applied for this reason, although, otherwise, the cost of haulage would have been cheaper. At the same time, he had come across cases where, with perfectly dry roads, the life of the horses employed was, notwithstanding, a very low one. It might be possible that this was due to the fact that horses drew heavier loads in proportion to their strength than ponies did, being frequently loaded to their maximum powers, while ponies, drawing one tub only at a time, were not, under ordinary conditions, working at their full strength. The relative strain in starting was consequently much greater in the case of horses.

Mr. A. L. Steavenson moved a vote of thanks to the writers of the paper, and recommended those members who wished to study the subject to read a book by General Morin on *Experiences sur le Tirage des Voitures.*

The vote of thanks was carried with acclamation.

The following "Notes on the Geology of Finland" were read by Principal H. P. Gurney:—

* *Trans. Fed. Inst.*, vol. xii., page 257.

NOTES ON THE GEOLOGY OF FINLAND.

By Principal H. P. GURNEY.

The Seventh International Geological Congress was held in St. Petersburg in September, 1897. It was at least as successful as any of its predecessors. The Organizing Committee spared no trouble to make the best possible arrangements. Every mineralogist and geologist in the Russian Empire, from the President of Honour, His Imperial Highness the Grand Duke Constantin Constantinovitch, the President of the Imperial Academy of Science, down to the students in the Universities, welcomed the visitors with heartiness and enthusiasm, and vied with each other in their efforts to show them all that was best worth seeing in their special districts. Expeditions were conducted to the Caucasus, the Urals, Esthonia and Finland. The last-named was one of the most popular. More than 150 representatives of nearly a score of nationalities entered their names for the excursion to the Grand Duchy. The great interest attaching to the remarkable development of pre-Cambrian crystalline rocks in the beautiful Land of Lakes was enhanced by the personal interpretation of the able and courteous Director of the Geological Commission of Finland, Dr. J. Sćderholm. Prof. Baron De Geer and Drs. Frosterus and Hackmann expounded the glaciation of the mainland, and Drs. Ramsay and Berghell took charge of parties during the visit to the island of Högland.

A remarkable persistence of land towards the north has long been recognized. All Finnish and Swedish geologists are agreed that the whole territory of Finland and Eastern Sweden is of pre-Cambrian age. There is no trace of mountain-making processes, nor of any considerable eruption of igneous rocks in this region during post-Cambrian and the youngest pre-Cambrian times. While in other districts geographical changes have over and over again completely transformed the surface of the globe, these northern lands have more or less successfully defied the inroads of the sea. During long ages, the rocks of this most ancient continent have been continuously worn away. They have furnished materials out of which many thousands of feet of newer strata have been

in turn constructed. For the most part they are sedimentary derivatives from yet older beds, and originally they must have been of enormous thickness, probably greater than that of all post-Cambrian formations.

More than once, with patriotic pride, Finns have boasted of the extreme antiquity of their fatherland. In a speech given at a banquet at Helsingfors in honour of the visit of the members of the International Geological Congress, an orator went so far as to trace a certain harmony between the geological structure of Finland and the national character. "Established as we are upon a solid soil," he said, "which is neither exposed to earthquakes nor to volcanic eruptions, we are a tranquil race, who, supported by good laws, never abandon the path of natural law-abiding evolution."

It is then to this far-off period, the most remote in the record of the rocks, that the Geological Commission of the Grand Duchy refer the chief formations of Finland. Followed into Lapland, beds of Cambrian age are found to rest upon them unconformably. They are classified in two great groups. The younger of these, which includes pre-Cambrian sediments, which are still clastic or semi-clastic, is separated by a distinct unconformity from the older rocks and called Algonkian—or Archæozoic—or Proterozoic. The latter are described as Archæan, but it should be noted that Dr. Söderholm does not accept the distinction between the Algonkian and Archæan which has been made in America. For him, Archæan is a term covering only the oldest pre-Cambrian basal beds, with only locally a distinct chronological value. In Southern Finland, each group is divided by an unconformity into two natural sub-groups. The unconformity among Archæan rocks is often obscured by metamorphism and by the intrusion of granite on an extensive scale. The upper formations of the Algonkian series are distinguished as Yotnian, the lower are called Yatulian. The former beds are represented by an olivine-diabase on the western coast in the Björneborg district, and on the eastern side by some gabbros lying to the north of Lake Ladoga. But the most noteworthy member of this series is the remarkable porphyritic granite called *rapakivi*, which occurs in several localities in southern Finland, its most extensive development being along the southern coast from Viborg to Lodovisa. This granite-covered tract stretches inland to the northwards for some distance, and at a moderate estimation extends over some 4,500 square miles. It is a handsome stone capable of receiving a good polish, and it has therefore been extensively used in the erection of the public buildings and monuments of St. Petersburg. The lighter-coloured variety is the more

durable. The darker variety has proved unable to resist the severities of the Russian climate. In interiors it lasts well, but exposed to weather it readily disintegrates, and the trouble and annoyance thus caused have given rise to the contemptuous name *rapakivi*, the rotting, or, decaying stone. An excellent example is found in that handsome feature of the northern metropolis, the celebrated Alexander column. This greatest monolith of modern times originally was 102 feet long, exclusive of pedestal and capital. The shaft has now been shortened to 84 feet. It is sadly fissured, and, although carefully repaired with cement, it is considered to be in a perilous condition.

Rapakivi is a hornblende-biotite granite. The characteristic of both varieties is the presence in a coarse-grained aggregate of phenocrysts of roundish ball-shaped orthoclase never found with crystalloid boundary-faces. The balls range generally from 2 to 3 inches in diameter, but are sometimes larger. Occasionally they contain zonal inclusions of other constituents, and they vary in colour from brownish-red to rose-pink. They are surrounded by a rind of oligoclase of greyish-green tint. The latter is said to be the part affected by the weathering when the orthoclase-nucleus falls out. Hornblende and biotite (var. lepidomelane) are present in equal quantities, and accessories are zircon, magnetite, ilmenite, apatite, and fluor. In the darker variety, the blackish quartz is irregularly bounded, but in the lighter the crystal-faces are well developed. We should also add that Finnish geologists sometimes apply this name *rapakivi* to all holocrystalline granitic rocks of pre-Cambrian age containing phenocrysts of orthoclase, even when the latter are not coated with oligoclase.

The Yatulian diorites, quartzites, and conglomerates are chiefly developed in the north of Finland. The only locality where the writer had the opportunity of observing them was the island of Högland.

Below the Algonkian strata, and separated from them by a marked unconformity wherever they occur together, we find the Archæan beds. The most interesting formations of the upper division of this series are the Bothnian Schists. Above them are granites, sometimes intrusive and sometimes exhibiting a gneissic character; and older than the Bothnian Schists are extensive beds of metamorphic granite, and Dr. Söderholm's "granitized mica-schists," which may perhaps be more accurately described as finely foliated gneiss. The upper Archæan group is well developed about Tammerfors, the younger beds lying more towards the north. The Bothnian Schists stretch from the Gulf

of Bothnia in considerable patches almost due east and west, passing between the granites and the town. In other districts, they are said to be represented by uralitic porphyries and gabbros. All these beds rest unconformably upon another series of granites, diorites, gabbros, schists, and gneiss. Among the pebbles in the Bothnian Conglomerates, there are fragments of syenitic granites and diorites, closely resembling the diorites connected with the older grey granites. The latter do not penetrate the younger schists, but in Lavia they are brecciated at this contact. These Archæan formations in turn overlie an unknown thickness of very ancient granitoid gneiss, which is developed in the district lying to the north of Lake Ladoga, and which, being identified by the Director of the Geological Commission as the most ancient rock in Finland, has been called by him Katarchæan.

The Bothnian Schists of Tammerfors are specially interesting, not only because their original conglomeratic character in certain places can be sometimes clearly traced, frequently in the Tammerfors district being remarkably fresh and distinct, and not unlike certain conglomerates on the western coast of Scotland in appearance, but also because they have been described as fossiliferous. But although one may theoretically admit that conditions during which life was possible probably obtained during a pre-Cambrian period far longer than that covered by the post-Cambrian systems already recognized, it was felt by many members of the International Geological Congress that extreme caution should be exercised in accepting the evidences of organic life at the remote epoch when the Bothnian Schists were being formed, seeing that they are separated from the Cambrian Series by three unconformities and the whole of the important series of Yotnian and Yatulian beds. The grounds on which the Geological Commission claim to have proved the existence of life during the Bothnian period are the not infrequent presence of carbonaceous matter in these phyllites (1) in thin bands, and also (2) lining small cavities, which are claimed as casts of fossils, and traces of structure in this carbon. In order that the members of the Congress might satisfy themselves by actual inspection of these phenomena, arrangements had been made to convey them in two large barges, roughly but sufficiently prepared for their accommodation, which were dragged by steam-tugs for 10 or 12 miles up Lake Näsijärvi, which lies to the north of Tammerfors. The party arrived at the locality in due course, and with some difficulty effected a landing upon rocks whose natural slipperiness was enhanced by the drizzling rain, for which we found Finland famous. The result might have been fore-

seen. Many worthy scientists soon lost their footing. Bruised and smarting, some refused further to imperil lives so valuable to human progress, and resolutely awaited our return. But the rest of us, after much struggling and scrambling, sometimes on all fours, over slimy rocks and greasy ledges, reached a certain belt of these phyllites, where Dr. Söderholm pointed to some curious calceolate impressions from 1 to 5 inches long and about 1 to $1\frac{1}{2}$ inches across. They are outlined by a weathered rim of a carbonaceous character, somewhat like graphite. They lie in bands approximately parallel to the slates—evidently of sedimentary origin—in which they occur. Sections have been carefully prepared and examined by the best microscopists of St. Petersburg. Traces of organic structure have been plainly found in this carbonaceous layer, which, be it remembered, seemed, at a liberal guess where we saw it, about 0·01 inch thick. Dr. Sederholm was convinced of their organic origin, and almost sure that they were remains of vegetable organisms. The party made their way back to their barges, some with abraded limbs and aching bones, silenced, if not completely convinced.

It will be remembered that Sir R. I. Murchison reported the occurrence of *Eozoon Canadense* in some schists near Viborg. But no reference was made to it by the Geological Commission.

Subsequently, the party landed on several other islands, and traced the Bothnian Schists from point to point. In some localities, there was unmistakeable evidence of their clastic origin, but no fossils were found.

Next day, the party travelled to Kulovesi, which lies an hour or two to the west of Tammerfors. They were then conducted to a cliff in some woods about $1\frac{1}{4}$ miles from the railway-station, where they were shown an interesting section of Bothnian Conglomerates metamorphosed into a fine-grained gneissic schist, rich in felspar, but with comparatively little mica. Although quite gneissic, the original conglomeratic character could be very plainly traced. In some places, lamination was observable, which was attributed to false bedding in the conglomerate.

It is calculated that the total thickness of the Bothnian Schists and interstratified Conglomerates may be not less than 13,000 to 16,000 feet.

A special train was at the service of the party, and much of our time was spent in it. Many localities were visited, where interesting geological sections occurred, either in railway-cuttings or in the adjacent country, especially such as were considered to establish the views held by the Commission. For example, near Orihvesi, some hours were spent in the examination of the contact between the Bothnian Schists and the granite-

rocks. In one portion of the section, the granite contained porphyritic crystals, which did not occur in other parts of it. The members of the Commission held that this granite should be referred to two distinct formations. The porphyritic granite was stated to be older than the schists which were deposited upon it, and which included fragments of it. Another part of the granite, which was non-porphyritic, and was stated to contain tourmaline, is evidently intrusive, and therefore younger than the gneiss in which its veins could be plainly traced. It was maintained that this being of a lighter colour and finer grain had no connexion with the older mass. This section was traced for more than a mile, for it was understood that the relative ages of the granites and the gneiss were considered of great importance in determining the age of large masses of granite to the south. There could be no doubt that the non-porphyritic granite was intrusive, but many of the party thought it by no means clear that the contact between the gneiss and the porphyritic granite was a mechanical one. Superficial observations failed to show any essential difference between the two granites. Even the porphyritic character was variable, and the tourmaline was apparently very local in its development. The so-called included fragments appeared to be parts of veins, and the colour was by no means constant. After an interesting discussion, in which widely diverging opinions were uncompromisingly expressed, most of the geologists present were unable to adapt the official view, as they were of opinion that the granite was all part of the same formation, and that it was intrusive and all younger than the schists.

The Geological Congress inspected many fine specimens of the metalliferous ores of Finland, not only at the museums at Helsingfors and St. Petersburg, but also at various localities visited in the Grand Duchy. At Tammerfors, for example, attention was specially invited to some curious water-worn concretions of iron ore, about 1 inch in diameter, said to be found in abundance in the neighbourhood. The time at the disposal of the party did not permit personal inspection of the mines. But numerous magnetite and spathose iron-ore deposits occur in profusion all over the country. Copper, tin, zinc, lead, and silver ores, auriferous sands and amber are also worked advantageously. Many of these are shown on Prof. Von Moeller's useful map of the ore deposits of Russia in Europe, published in 1878. Perhaps the best known copper and tin ore beds are those of Pitkäranta on the north-eastern shore of Lake Ladoga, but the production of tin is not large. An excellent description of these interesting mines, by Dr. Törnebohm,

will be found in the *Geologiska Föreningens i Stockholm Förhandlingar*, 1891, vol. xiii., page 313. That writer's map shows the Rapakivi outcrops occurring quite near the ore deposits.

In Southern Finland, the ancient rocks are sometimes covered with glacial clays and sands. Post-glacial beds with numerous shells such as *Cardium*, *Litorina*, *Mytilus*, *Tellina*, etc., also occur, not infrequently forming terraces, or raised beaches. But the most noteworthy remains of the Quaternary period are long high narrow ridges, chiefly composed of sands and gravels, and distributed widely without apparent reference to present physiographic features. These åsar are similar in some respects to the raers of Norway, the kames of Scotland, and the eskers of Ireland. Sometimes they cannot be satisfactorily distinguished from the arenaceous glacial beds on which they stand, but more often they rest directly upon the ancient rocks. These huge embankments pass in long windings across vast tracts of country. Some of them can be traced right across Finland and into Scandinavia. Occasionally they present striking resemblances to river-courses, coalescing and forming hollows, which are frequently occupied by lakes. Sometimes the åsar are composed of coarse gravel, shingle or earthy detritus. The stones are waterworn, especially at moderate elevations. Erratic blocks are rare in their interiors, although they are not uncommonly scattered over their surfaces. In finer grained beds the stratification is often well marked and false bedding not infrequent. In some cases, the planes of stratification towards the surface more or less correspond to the external slope, which seem to indicate that these åsar are original forms of deposit, and not the result of the erosion of more extended strata. Some of them are 200 feet high, and, as the country is gently undulating and well furnished with wood and water, magnificent panoramas are obtained from their highest parts. At the base, they are sometimes 500 to 600 feet across. Tammerfors, the Manchester of Finland, is partly built on an ås, which, forming a natural dam, keeps the waters of Lake Näsijärvi at a sufficient height above the level of the southern lake, Pyhäjärvi, to obtain water-power for all the mills and factories of the town.

No organic remains have been found in åsar, but their external slopes are sometimes covered with an argillaceous deposit containing shells of *Arca*, *Astarte*, *Cyprina*, and *Natica*.

The party had the privilege of hearing many addresses in various languages from eminent geologists, who attempted to explain the origin of the åsar. The theories were very conflicting, but might be grouped as

glacial, fluviatile, or marine. The great length, the narrow section, the winding character, and the branching of the åsar present peculiar difficulties. They are clearly to be distinguished from the terminal moraines of glaciers, the latter being unstratified and more limited in extent and lying with their axis at right angles to the glacial striæ; but it was argued that they might have been produced by floods caused by the rapid melting of vast masses of snow and ice. Others suggested that they were the retreating deltas of turbid streams, issuing from the base of glaciers during a period when they were shrinking. Possibly they might indicate the courses of persistent channels in the ice floes, when the country was covered by the glacial sea, along which, for considerable periods of time, icebergs travelled, gradually dropping the solid matter they conveyed. Another explanation was that they marked ancient river-courses. In a country covered with sand, rivers formed their beds, and then deposited coarser materials throughout their length, which resisted the denudation that removed the circumjacent strata. Lastly, they were compared with the submarine banks sometimes formed within the sphere of action of tidal currents sweeping along the shore. Those of us who were not committed to any theory thought that no single one then explained to us could satisfactorily interpret all the phenomena to be accounted for.

At the close of the excursion the party visited a rocky island in the middle of the Gulf of Finland called Högland, to which the writer had already referred. Although only about 6 miles long and less than 2 miles across at its widest part, it bears to Finland a geological relation similar to that which Britain bears to the Continent of Europe, for most of the formations of the mainland are represented upon it. It also offers some fine examples of glacial erosion, and its raised beaches clearly indicate the variations in level of the ancient seas.

The eastern side of the island has a picturesque outline, formed by a series of hills which stretch from north to south, and sometimes raise their summits upwards of 500 feet above sea-level. These highlands are covered with a quartz-porphyry, which our guide, Dr. Wilhelm Ramsay, who had spent some years in working out the geology of Högland, correlated with the rapakivi of the mainland. If so, these strata would be of Yotnian age. They are certainly the youngest of these insular ancient beds. The porphyry generally exhibits a micro-granitic or micro-pegmatitic structure, with large crystals of orthoclase and quartz, but it becomes felsitic and even vitreous near its contact with the older rocks.

That it has been raised vertically since its formation we may conclude from the friction-breccias which it contains along the eastern coast of the island.

The quartz-porphyry contains fragments of an interesting rock which Dr. Ramsay called a labrador-porphyrite, or porphyritic diabase. This is an eruptive rock of dark green colour and fine-grained texture. It contains slender, light-coloured felspar laths and much epidote. It underlies the porphyry, and is accompanied by beds of tuff containing fragments of the conglomerate on which it rests.

This conglomerate is a hard sandstone with pebbles of the subjacent older quartzite. It has a slight dip towards the east, and is of about the same age as some fine-grained quartzites by which it appears to be represented in certain localities, as on the west of the rock of Majakallio, and which are changed into hornstone, where overflowed by the labrador-porphyry.

Much more ancient than the above are another series of quartzites and some eurites. These beds have been violently dislocated, folded, contorted, and partly denuded before the deposition of the newer quartzites and conglomerates. At Purjekallio and Somerinvuori, the latter form the tops of the hills, and rest upon the abraded folds of the first-mentioned beds. Owing to this unconformity, the older quartzites and eurites are considered by Dr. Ramsay to be of Yatulian age.

In the north and south of the island, beds of highly-contorted gneiss and crystalline schists are found. In the centre of Högland, these strata appear to be represented by a gabbro, composed of labradorite, partly replaced by saussurite, oligoclase, actinolite, and uralite. These are evidently the most ancient beds in this island, and Dr. Ramsay called them Archæan. They have all been strongly contorted, and sometimes are much folded. A reddish granite has intruded into all of them, and they frequently contain veins from the parent mass, which comes to the surface in the extreme north and south of the island. This granite never penetrates the ancient quartzites, or eurites, or any of the newer rocks. It is therefore considered to be the youngest representative of the Archæan formations of Högland.

Another party devoted their day entirely to the glacial geology of the island. They made a profitable excursion under the direction of Dr. Berghell. The section who accompanied Dr. Ramsay were primarily intent on studying the more ancient rocks, but incidentally many traces of ice-action were seen. All regretted that it was necessary to return to St. Petersburg that night, as the first meeting of the International

Geological Congress was held on the following afternoon. But every member of the Finland expedition will always remember the great kindness, courtesy, and generous hospitality with which they were everywhere received during their brief travels in that interesting and ancient country, and they feel that their grateful acknowledgments are specially due to Dr. Séderholm and Dr. Ramsay and the staff of the Geological Commission.

APPENDIX.—PRE-CAMBRIAN FORMATIONS OF SOUTHERN FINLAND.

	Formations.	Grand Duchy of Finland. Dr. J. J. Séderholm.	Högland Island. Dr. M. W. Ramsay.
ALGONKIAN FORMATIONS.	Yotnian.	Olivine-diabase. Sandstone. Rapakivi Gabbros.	Quartz-porphyry. Labrador-porphyrite. Conglomerates and quartzites.
		UNCONFORMITY.	
	Yatulian.	Absent in Southern Finland, represented in Northern Finland by quartzites, etc.	Quartzites and eurites.
		UNCONFORMITY.	
ARCHÆAN FORMATIONS.	Upper Archæan.	Intrusive granites. Red gneissic granites Bothnian Schists and Conglomerates. Uralite porphyrites. Schists.	Red intrusive granite. Uralitic-gabbro
		UNCONFORMITY.	
	Lower Archæan.	Granites, gabbros, etc. Gneiss and crystalline schists.	Gneiss and crystalline schists.
	Katarchæan.	Granites and gneisses of Eastern Finland.	

Prof. H. LOUIS said that he had nothing to add to what Principal Gurney had said, as his own travels during the course of the International Geological Congress in Russia lay in a different direction he having

crossed Russia. The Department of Mines in Finland kept an accurate account of mining matters: they washed a little gold out of the gravel in some places, and worked a little tin and copper at the Pitkäranta mines, lying in granite, and worked on a very small scale. The principal mining industry of the country was iron ore, dredged from the beds of the lakes, and smelted in small blast-furnaces with charcoal, the method being, he thought, practically identical with that which he had described as employed in the Urals.* About 5 to 10 tons of tin, 300 to 400 tons of copper, 60,000 to 70,000 tons of iron ore, and about 150 to 300 ounces of gold would fairly represent the annual mineral output of the Grand Duchy of Finland.

Mr. A. L. Steavenson said that during the last few years there had been a deficiency of geological papers, and he hoped that they would have further communications from Principal Gurney. As an aid to the proper appreciation of such papers, he would recommend the members to read Prof. Sedgwick's books; also the life of Sir R. I. Murchison, by Sir A. Geikie; they would also find *The Founders of Geology* a most interesting work, and one which would lead the most obtuse person to enjoy geological research. Principal Gurney had referred to the way in which the visitors to Russia had been received by Prince Constantine, but this was no novelty, for when Sir R. I. Murchison visited Russia he was not only received by Their Imperial Highnesses, but he received considerable help from the Emperor Nicholas; and from what he (Mr. Steavenson) had read of the life of Sir R. I. Murchison, he was inclined to hold a high opinion of the Russian people.

Principal Gurney's paper was interesting also because it dealt with the first rocks in which it had been found that life of any kind had prevailed; Sir R. I. Murchison also mentioned certain rocks in Scotland where life was first found, but they were not told whether these rocks actually held organic remains or whether it was merely contended that at certain periods they had done so. He had great pleasure in proposing a hearty vote of thanks to Principal Gurney for his interesting paper.

This motion was cordially adopted.

Principal Gurney acknowledged the vote of thanks, and said it was repeatedly impressed upon the visitors to Russia that the only thing wanted to develop the mineral wealth of Finland was capital, and the hope was freely expressed, that, on their return home, they would make

* *Trans. Fed. Inst.*, vol. xiv., page 368.

such reports as would induce the capitalists of this and other countries to see the matter in the same light. He had the advantage of travelling with men who had studied the district, and they gave lucid descriptions, which he had imperfectly endeavoured to convey to the members in his paper, as well as the reasons which prevented him personally from accepting all of the conclusions of Geological Commission of Finland.

Mr. H. T. Newbigin read the following paper on "The Siliceous Iron-ores of Northern Norway":—

THE SILICEOUS* IRON-ORES OF NORTHERN NORWAY.

By H. T. NEWBIGIN.

For some years, attention has been directed to the question of securing additional sources from which to derive our iron-ore supplies, and especially has this been the case since it became apparent that the best Bilbao iron-ores were being rapidly exhausted.

The rapid development since 1891 of the Gellivara iron-mines in the north of Sweden directed attention to the possibility of securing a similar class of iron in Norway, where, owing to the action of the Gulf Stream, ice-free harbours may in most places be found; and interest in this matter was very much increased by a paper,† read by Mr. Jeremiah Head, before the Iron and Steel Institute, in 1894, in which he spoke hopefully of several of the deposits in the north of Norway.

Of late years, a considerable amount of research-work has been done among the better known of these, and many efforts have been made by the owners to induce capitalists to take up their working. In 1894 to 1895, an attempt was made to develop one of these deposits, which, from the reports made upon it, promised to become a successful iron-mine. Mining operations were commenced in October, 1894; in December of the same year, the writer went to Norway to look after the interests of the lessees in the matter, and during a stay of about 9 months he was able, from his own observations of this particular occurrence, and of many others which he visited—as well as from published and private reports by reliable experts in Norway—to collect some information about these iron-ore occurrences, which he trusts may be of interest to the members.

* This term is used to distinguish the iron-ores from the many deposits of titaniferous iron-ore found in the south of Norway and also within the last 2 years in the extreme north on Stjernö. This last deposit is said to give an analysis as follows:—

Iron	63·740
Titanic acid	6·700
Silicic acid	2·650
Phosphoric acid	trace.
Sulphur	0·018
Lime	1·450

† "Scandinavia as a Source of Iron-ore Supply," *Journal of the Iron and Steel Institute*, 1894, vol. xlv., page 47.

The iron-ore deposits which he will describe, lie between latitudes 66° and 68° north, and, for the sake of clearness, will be considered under the names of the places with which they are usually associated.

Fuglstrand and Skravalaa.—The deposits, with which the writer was immediately concerned, are situated on the Elvsfjord, a branch of the Ranenfjord, and lie about 66° 15′ north latitude and 13° 30′ east longitude.

The iron-ore occurs along the top of a mountain on the western side of the Elvsfjord (Figs. 1 and 2, Plate VIII.) at an elevation of about 700 feet in the north, rising to about 2,000 feet, at Skravalaa, in the south. The Elvsfjord is usually frozen for about 4 months in the winter.

The deposits are supposed to be of Cambrian age and to belong to the micaceous-schist-marble series (*Glimmer-skifer-marmor* group) of Norway, and, as is the case with all of these deposits, occur in intimate connexion with a very thick layer of limestone (or marble), which lies to the east of the iron-ore belt, and separated from it by a layer of micaceous schist.

The strike of the strata is roughly north north-east and south-south-west, and the dip, mainly to the west, varying from 70 degrees to vertical. The strata, except in the extreme north, are intersected in every direction by very thick veins of granite, so that at least one half of the surface consists of this rock, and in driving adits during research-work it was constantly found.

The total length of the ore-bearing zone is 4 to 5 miles, and the width varies from 1,000 to 1,200 feet (off which one half may be deducted for granite), and may be described as micaceous schist, impregnated in a very varying degree with iron, hornblende, and epidote, together with apatite, garnet and quartz.

In many places, samples may be knocked off at the surface containing 50 to 53 per cent. of iron, and this content, coupled with the great extent of the ore-bearing zone, and the fact of nearly all the rock weathering to the same colour, led many engineers to attach an importance to this locality which further examination has disproved.

The research-work, which, as already stated, was commenced in October, was carried on until the following July (with the exception of a stoppage of about 3 months in the winter) when it was finally abandoned, owing to the ore being found to be of too poor a quality to pay for working.

The research-work consisted of :—

(*a*) Surface-examination of the outcrop by means of trenches cut through the overlying soil, etc., at right angles to the strike of the strata.

(*b*) By means of magnetometer-surveys, or, in other words, by determining from the greater or less dip of a magnetic needle the proportionate mass of the underlying ore-deposits.*

The measured angles of dip at each point are recorded upon a similarly divided chart, and by drawing connecting lines through all the points of equal dip a number of irregular figures are obtained within each other, showing where the greatest mass of iron-ore may be looked for.

(*c*) By means of mining at the localities which showed the best indications by the two previous methods. The mining was carried on at, in all, about twenty different localities (some of which are shown on Fig. 2, Plate VIII.), and consisted either of adits driven horizontally or at right angles to the dip of the strata or of surface-quarrying.

(*d*) By chemical analyses of the ore obtained (of which some forty or fifty were made).

The above mentioned research-work failed to show any place from which concentrated iron-ore could be taken, or that such was likely to be found.

The true veins of iron-ore, containing 48 to 53 per cent. of iron, were found to lie in lenticular deposits of insignificant thickness between, or gradually changing into, epidotic or hornblendic rock impregnated with a much smaller percentage of iron, so that samples similar in appearance and taken close together were found to contain widely different percentages of iron.

Two kinds of iron-ore were found, viz. :—Hæmatite, in the form of micaceous iron-ore (*jernglimmerskifer*), containing in the best samples about 53 per cent. of iron changing into iron-impregnated epidotic rock; and magnetic iron-ore, containing up to 50 per cent. of iron changing into hornblendic or epidotic rock.

In no case were either of these classes of ore found in veins of sufficient thickness to enable them to be worked without the poorer surrounding rock, nor could the ore, with any reasonable amount of

* In making a chart after this system the surface of the ground to be examined is divided off into squares, having sides 10 or 12 feet long. The angle of dip is measured at each of the intersecting points by means of an instrument called a magnetometer, which consists chiefly of a dipping needle and a small magnet supported on a projecting arm so as to hold the needle normally horizontal. The dip of the needle is measured by a fixed scale, and the instrument is mounted on a tripod.

screening, be brought up to 50 per cent. of iron, which was considered to be the very lowest permissible amount.

The following analyses (which were made at the lessees' laboratory in Norway) are instructive, as showing the great variation in the percentages of iron in the ore that was taken out during the mining operations :—

Classification of Iron-ore.	Number of Samples.	Percentage Contents of Iron.
Containing over 60 per cent.	1	63·8.
,, 55 to 60 ,,	1	58·2.
,, 50 to 55 ,,	5	50·2, 51·0, 51·1, 51·9, and 53·3.
,, 45 to 50 ,,	10	45·1, 45·3, 45·4, 45 5, 46·0, 47·1, 47·4, 48·2, 48·3, and 49·8.
,, 40 to 45 ,,	8	40·5, 40·7, 41·7 42·0, 42·6, 43·6, 44·0, and 44·6.
,, 35 to 40 ,,	7	35·2, 35·5, 38·0, 38·5, 38·5, 38·9, and 39·5.
,, 30 to 35 ,,	1	31·5.
,, 25 to 30 ,,	2	28·0 and 29·0.

If the two highest and three lowest samples are taken away, the remainder fall between about 38 and 52 per cent., with an average of about 44 per cent., and this, in the writer's opinion, and in that of two Norwegian experts whom he consulted in the matter (Prof. Vogt, of Christiania, and Bergmester A. S. Bachke, of Trondhjem), is the highest percentage of iron which could be obtained from ore worked on a practical scale at this place. Such an ore, which would contain 27 to 30 per cent. of silica and about 0·20 per cent. of phosphorus, is of no commercial value.

The following is a complete analysis, after drying at 212° Fahr., by Messrs. Pattinson & Stead, Middlesbro', of the best samples of the two classes of ore found :—

	Hæmatite Iron-ore. Per Cent.	Magnetic Iron-ore. Per Cent.
Peroxide of iron	67·500	51·357
Protoxide of iron	8·036	21·280
Protoxide of manganese	0·186	0·093
Alumina	2·860	2·970
Lime	1·674	1·932
Magnesia	1·254	1·404
Silica	17·100	19·050
Sulphur	0·013	0·022
Phosphoric acid	0·207	0·540
Titanic acid	0·550	0·450
Arsenic	Nil.	Nil.
Copper	Nil.	Nil.
Lead	Nil.	Nil.
Combined water	0·400	0·720
Totals	99·780	99·818
Iron	53·500	52·500

The above analyses are interesting, when taken in connexion with the result of the workings at Fuglstrand, and the writer is of opinion that many of the other Norwegian iron-ore deposits of the same class would yield no better result from practical working.

It may also be noticed that the percentage of silica varies in almost direct proportion to the iron, and if the iron-percentage of any given sample (holding over 40 per cent.) be deducted from the pure oxide (70 per cent. for hæmatite, Fe_2O_3, and 72·4 per cent. for magnetic iron-ore, $Fe_2O_3 + FeO$), the result will be roughly the percentage of silica.

Hæmatite, in the form of micaceous iron-ore, was in the best samples of a somewhat friable nature, of a grey colour, and with considerable lustre: while the best samples of magnetic-ore were hard and finely granular, of a blackish-grey colour, with but slight lustre and highly magnetic.

Seljelid and Haggli.—On the opposite side of the Elvsfjord, lying to the east of a thick marble deposit, an iron occurrence similar to that of Fuglstrand is found.

The strike of the strata is about north-east and south-west, with a dip to the north-west of about 30 degrees. The iron-bearing schist may be followed from the edge of the fjord for some 2 to 3 miles inland, rising to an elevation of 600 or 700 feet.

The first-named of these two localities, which lies next the fjord, was explored in the summer of 1895 by a small British syndicate formed for the purpose; the result, however, showed that the ore was of no commercial value. Two fair samples from the best outcrop gave respectively 39·720 and 39·90 per cent., while other general samples gave as low as 23·54 per cent. of iron.

The second locality (which really forms a continuation of the first, but is held by different owners) has not been explored: the analyses, however, taken from samples of the outcrop show a rather better result, the following being some of them:—Total iron, 53·751, 46·56, 31·212, and 57·344 per cent., which is very similar to the results obtained at Fuglstrand.

A partial analysis of two samples gave the following results:—

	No. 1. Per Cent.	No. 2. Per Cent.
Total iron	46·560	57·344
Lime	1·530	1·070
Silica	25·100	16·080
Sulphur	trace.	trace.
Phosphoric acid	0·442	0·428

The best of these analyses, however, cannot be taken as indicating the percentage of iron obtainable in ore worked on a practical scale, as the veins of ore are in small proportion to the poorer iron-impregnated rock.

Although the Haggli field has an advantage over Fuglstrand in not being cut up with granite-veins, yet it is very doubtful if it would yield any better result by proper exploration.

Mösjöen.—The deposits at this place are described by Prof. Vogt as being similar to those at Fuglstrand, from which they are 18 or 20 miles distant, in a south-westerly direction The same authority in one of his official reports* describes them as lying 2 to 3 miles from the end of Vefsenfjord, and consisting of about ten parallel layers, having a strike south 30° east and north 30° west, with thicknesses varying from 5 to 16 feet, these thicknesses including, however, a large proportion of schist.

The deposit consists partly of micaceous iron-ore (*jernglimmer-skifer*) and partly of magnetic iron-ore mixed with epidote, quartz, hornblende, mica, and garnet.

Analyses of picked samples show from 46·13 to 63·17 per cent. of iron, with an average of about 53 per cent. These analyses, however, are of no practical value as indicating the percentage likely to be obtained by work on a practical scale. The phosphorus in the ore at this locality is the highest found in the iron-ores of this part of Norway, ranging from 0·24 to 1·14 per cent., with an average of 0·48 per cent.

The writer is not aware whether these deposits have been opened out to any extent or not.

None of the foregoing occurrences can be considered as being of any possible value as sources of iron-supply. They are described by Prof. Vogt as being similar to the deposits known as *skarnberg-skifer*,† which are met with alongside the true iron-ore veins at Arendal, Persberg, and Dannemora in Sweden, and although picked pieces may be taken which are fairly high in iron, yet for the most part they consist merely of iron-impregnated rock, and cannot (properly speaking) be described as iron-ore deposits: the siliceous matter being so intimately mixed with the iron oxide as to make the necessary separation impossible.

It is essential, therefore, to make a thorough examination of any of these siliceous deposits in Norway before concluding negotiations with the owners, if it be proposed to work them.

* *Norges Geologiske Undersögelse*, No. 15, "Dunderlandsdalens Jernmalmfelt."

† Literally: dirty schistose rock.

In addition to these valueless deposits, there are, however, several other occurrences in this part of Norway which—although yielding average analyses very little higher in iron than is obtained from the first mentioned—yet owing to the silica being contained either in layers or in veins, it may be possible so to treat the mineral as to obtain a marketable ore.

The following are some of the localities which might be developed on a practical scale.

Tomö.—These deposits are found on an island situated north of the entrance to the Ranenfjord and lie on the eastern side of the island, at the base of a high mountain which rises abruptly out of the surrounding land, and is supposed to resemble a thumb: from this the island derives its name of Tomö or Thumb Island.

The iron-ore is found in what appear to be large lenticular deposits, lying parallel to each other, with a strike north-north-east and south-south-west, dipping into the base of the mountain at an angle of from 20 to 35 degrees, and varying in thickness at the outcrop from 4 to 18 feet.

The formation in which the deposits occur is supposed to be of Archæan age, and is described as consisting of calcareous mica-schist, granular limestone, hornblendic schist, quartoze and gneissic rock.

The ore is found between micaceous schist and limestone, the former being usually the hanging-wall.

In 1894 and 1895, a considerable amount of research-work was done here, and at one spot a large cave was quarried out, from which at least 1,000 tons of ore have been taken. This working is about 280 feet above sea-level and about 900 feet from the shore (where there is deep water), and appears to be in the most important seam. Its outcrop has been followed for about 6,000 feet, and diminishes in thickness at both sides of this point; on the other hand, the thickness which is here about 18 feet at the outcrop seems to increase in the dip, so that although a very considerable amount of iron-ore could be obtained, it would be impossible to make other than the roughest of estimates as to the probable quantity. The other parallel deposits do not appear to be of very great importance: they are, however, said to consist of magnetic and micaceous iron-ore.

This main seam of ore (wherein is the trial-working, which has been named the Forsland mine), consists of specular iron-ore of a very hard character and of considerable purity. It has this great difference from the

ore at such places as Fuglstrand, in that it occurs in a clearly-defined bed and does not gradually pass into mere iron-impregnated rock, and that, whereas at Fuglstrand the ore is intimately mixed with the siliceous matter, at this place, the combined siliceous matter is small, and in picked samples seldom over 7 per cent. There are, however, small veins of quartz running in all directions through the ore, which cause the percentage to rise to about 28, in an average sample taken over the whole thickness of the vein, and to about 22 on a fair sample of screened ore. It is evident that, in order to develop this mine, some means would have to be devised of getting rid of some of the siliceous matter, other than by ordinary sorting of the mined material.

As the ore is not magnetic, this cannot be accomplished by electro-magnetic separation. If, however, the ore were broken, either by hand or machine, to about the size of road-metal, and carefully picked on travelling-belts (similar to coal-belts), it is probable that an ore containing about 55 per cent. of iron, 15 per cent. of silica, and 0·25 to 0·30 per cent. of phosphorus could be obtained here at a low cost.

Such an ore would probably find a market as a basic bessemer ore at 8s. to 9s. per ton, c.i.f., and with careful management could no doubt be made to pay at this price.

The following analyses of samples of ore from Tomö were made in the laboratory at Fuglstrand by the lessees' chemist, Mr. S. W. Williamson:—

Samples.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Protoxide of iron ...	0·410	0·424	1·614	1·805	2·164	4·072
Peroxide of iron ...	89·556	91·040	68·443	59·467	70·583	62·569
Silica	7·100	3·560	22·230	28·620	19·770	24·570
Alumina	1·493	0·898	2·357	3·482	3·508	3·385
Protoxide of manganese	trace.	trace.	0·175	0·157	0·112	0·130
Lime	0·840	2·310	2·590	3·170	1·850	2·610
Magnesia	0·263	0·299	0·778	0·796	0·191	0·605
Phosphoric acid ...	0·346	0·648	0·636	0·476	0·604	0·801
Carbonic acid	0·056	0·556	—	—	—	—
Sulphur	0·009	0·012	trace.	trace.	trace.	trace.
Loss on ignition ..	0·136	0·440	1·329	2·090	0·010	1·262
Titanium	—	—	slight trace.	nil.	slight trace.	slight trace.
Totals	100·209	100·187	100·152	100·063	98·792	100·004
Iron	63·009	64·058	49·166	43·031	51·091	46·965
Phosphorus	0·151	0·283	0·278	0·208	0·264	0·350

No. 1, Picked sample from best screened ore.

No. 2, Picked sample from second quality screened ore.

No. 3, Average sample from a cargo of about 200 tons.

No. 4, Average sample taken over the whole thickness of the main seam of ore at the innermost face of the working.

No. 5, An average sample taken from a smaller heap of screened ore from the main seam.

No. 6, Sample taken from the seam of ore above the main seam.

The above analyses, and many others, fail to show that the percentage of phosphorus exists in any definite relation, either to the percentage of iron or to the position in the vein at which the sample was taken; there appears, therefore, to be no hope of this ore ever being found suitable for steel-making by the acid process.

*Dönnesö.**—A few miles south-west of Tomö is another island on which two separate groups of iron-ore veins are found, one on the north-western coast called the Rulvaag deposits, and another some 3 miles north-east of this, called the Saravaag deposits.

Geologically, the island is supposed to be of Cambrian age, the predominating rocks being mica-schist, argillaceous mica-schist, actinolitic slate, and limestone; granite is also found on the eastern side of the island. The iron-ore veins are situated on the seaboard, and are well placed for cheap working and easy loading.

The Rulvaag deposits consist of a group of parallel lenticular beds striking north-east and south-west, and having a dip to the south-south-west of 20 to 50 degrees. The first of these beds has a thickness of about 12 feet and may be followed for a length of some 300 feet. It consists of coarse crystalline magnetite, alternating with specular iron-ore. Parallel to this bed are three or more smaller beds, varying in thickness from 7 to 10 feet, and separated from one another by limestone and gneiss. The ore is associated with epidote, calcite, and quartz, and the deposits have been opened out by twelve small shafts and trenches.

The Saravaag veins have not yet been thoroughly explored, but appear to consist of three beds striking east and west, with a dip of about 20 degrees to the south. The principal vein has a thickness of about 20 feet and has been followed for a distance of 1,500 feet. It consists of specular iron-ore mixed with magnetite. The ore is of a hard lumpy character, and is found in lenticular beds connected by narrow belts.

The following analyses were made, by Dr. A Tomm, of samples taken from the Rulvaag deposits in 1887 :—

* This information is chiefly derived from a report by Mr. Alfred Hasselbom.

	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.	No. 4. Per Cent.
Peroxide of iron	1·570	87·140	64·860	69·140
Magnetic oxide	82·450	3·730	12·430	12·430
Protoxide of manganese ...	0·280	0·170	0·260	0·170
Magnesia	1·040	0·250	0·940	0·650
Lime	3·200	3·100	5·900	3·800
Alumina	1·740	0·130	0·920	1·500
Titanic acid . .	trace.	trace.	trace.	trace.
Silica	7·800	3·900	10·800	9·900
Phosphoric acid .. .	0·465	0·166	0·410	0·547
Sulphur	0·146	0·011	0·014	0·015
Copper	0·005	trace.	trace.	trace.
Combined water	0·300	1·900	2·100	1·000
Totals	98·996	100·497	98·634	99·152
Iron	60·000	63·700	54·400	57·400
Phosphorus	0·240	0·073	0·180	0·240

It would appear from samples that the writer has seen from this locality that these analyses have been taken from selected pieces, and not from average samples of screened ore.

If this be the case, it is probable (judging from the results at other places) that ore worked on a practical scale would contain 7 to 10 per cent. less iron than these analyses show, and would hold proportionately more silica.

Naverhaugen.—These deposits are perhaps the best known of any in northern Norway; they were first opened out in 1875, and have been recently further explored.

The iron-ore is found over a length of about 7 miles, and occurs on an irregular plain between two ranges of high mountains. This plain connects the Skjärstadfjord—a branch of Saltenfjord—on the south, with South Foldenfjord on the north, and rises at its highest point to an elevation of about 600 feet.

There is water-communication to within 3 miles of the main deposits, but the fjord is too shallow to be navigable for any but small boats. The nearest convenient position for a loading station appears, therefore, to be on the Skjärstadfjord, at a distance of about 8 miles from the principal occurrence of ore.

The deposits consist of specular iron-ore mixed with a little magnetite. The ore is granular, of a bright lustre, and may be, on the whole, easily crushed: it occurs in veins of varying thickness in close proximity to a large deposit of granular limestone. The strike of the veins is about

north-north-east and south-south-west, with a dip to the west-north-west of 45 to 60 degrees, the adjoining strata being usually limestone and schist.

Although these iron-ore veins may be traced for so great a distance, the thickness is generally too small for them to be of any value. Occasionally, however, they widen out to a considerable thickness, as at Mastukrogen, where a vein may be followed for a distance of 1,200 to 1,500 feet, with a thickness of 30 to 40 feet; and this appears to be the largest deposit. There are also two thick veins of ore about 2 miles north of this locality, and they extend for a considerable distance.

The extent of these thick veins is not great at the outcrop, but it would appear from borings, which have been made, that they maintain their thickness in depth, and thus there is no doubt that a considerable amount of ore could be mined from them.*

A large sum of money has been expended first and last in opening out these deposits, and many proposals have been made for working them on a practical scale, but without result, owing partly to the large initial cost necessary for railways, etc., and partly to the want of a cheap means of getting rid of the siliceous matter with which the ore is associated. The bulk of this siliceous matter occurs in parallel layers interstratified with the ore: these are seldom more than 6 inches apart, and are usually much closer. The iron-ore itself is, however, of almost uniformly good quality.

The following is a partial analysis made by Mr. S. W. Williamson of two samples taken by the writer. The first sample consisted of 3 pieces of average quality, and the total iron was 56·499 per cent. The second sample was 1 piece of best quality, and the total iron was 63·861 per cent.; silica, 7·340 per cent.: phosphorus, 0·053 per cent.; manganese, 0·280 per cent.: with traces of sulphur and titanium. The phosphorus in this sample is below the average. An analysis such as the above could not, however, be obtained from a great bulk of ore, dressed and sorted by hand in the ordinary way. As an example of this, a cargo of some 700 tons which was sent to Scotland in 1887, as a sample, yielded only 46 per cent. of iron.

In order to obtain an ore holding, say 60 per cent. of iron, some other means of dressing would have to be adopted. If the ore were crushed and picked on travelling-belts, no doubt the percentage of iron could be very much increased, but this would cause a large amount of small to be

* It has been estimated that 1,500,000 tons of 50 per cent. ore could be extracted from the Mastukrogen deposit by an adit driven in horizontally at the foot of the hill on which it is situated.

made, so that probably some system of washing would also have to be used. If this were done, it might be found possible to reduce the percentage of phosphorus at the same time, and thereby very considerably increase the value of the product. On the other hand, there is of course the difficulty of using this finely-crushed ore.

The phosphorus is found to exist in the form of apatite in minute crystals irregularly distributed through the iron oxide, and almost entirely absent from the siliceous matter. The average content of phosphorus taken over some 46 analyses is given by Prof. Vogt at 0·192 per cent. The same authority supplies the following complete analyses of four average samples taken during the progress of some of the mining operations :—

Samples.	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.	No. 4. Per Cent.
Peroxide of iron	74·60	76·70	76·75	59·60
Protoxide of iron	8·78	10·81	9·96	1·58
Silica	10·02	8·25	8·33	30·40
Alumina	0·74	1·04	0·61	2·56
Protoxide of manganese	1·28	0·79	0·59	0·95
Lime	3·59	2·35	2·90	2·91
Magnesia	0·68	0·67	0·50	1·58
Phosphoric acid	0·39	0·30	0·30	0·58
Sulphur	0·012	0·11	0·009	trace
Totals	100·092	101·02	99·949	100·16
Iron	59·06	62·10	61·48	42·95
Phosphorus	0·17	0·13	0·13	0·25

Mr. Otto Gumalius, a Swedish mining-engineer, who has devoted much attention to the Næverhaugen iron-ore deposits, estimates the sum necessary to open them out on a practical scale at £48,000, which includes drilling-machines, crushing and electric-lighting plant, water-turbines (to drive which he proposes to utilize a neighbouring waterfall), houses, railways, rolling-stock, and loading-station. With this expenditure he calculates to produce 102,000 tons per annum of 60 per cent. ore at a cost of 10s. 6d. per ton delivered in Great Britain, ore which he values at 13s. per ton.

Fuglvik and Ormli.—On the north of Lake Langvand, and situated about 5 miles from the innermost end of Ranenfjord, are found at least four parallel layers of iron-ore, stretching from north to south for a distance of about 3,500 feet, and dipping at a slight angle to the north-east. The thickness of these beds varies from 8 to 12 feet : they consist of specular iron-ore (somewhat similar to that at Næverhaugen), and magnetite, both of which, however, contain also a great deal of siliceous

matter. The adjoining strata are limestone and schist. These deposits were worked, in the early part of the present century, to supply some blast-furnaces near Trondhjem, and much of the best ore has been removed.

The following * are average analyses of some of the best samples taken at Fuglvik, but, to obtain this quality a large amount of screening would be necessary:—

Samples.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No 6.	No. 7.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Peroxide of iron ..	74·86	68·30	71·64	69·00	73·28	84·14	16·77
Protoxide of iron ...	2·57	3·08	3·21	4·63	1·80	1·54	72·08*
Silica	15·20	22·80	18·50	19·25	15·70	10·85	5·75
Alumina	0·96	1·07	0 83	1·08	0·94	0·34	0·60
Protoxide of manganese	0·27	0·38	0·26	0·45	0·41	0·23	0·38
Lime	4·20	2·50	3·95	3·65	5·50	2·25	2·45
Magnesia	0·84	0 83	0·92	0·65	1·17	0·14	0·68
Phosphoric acid ...	0·568	0·520	0·446	0·829	0·813	0·197	0·751
Sulphur	0·010	0·018	0·018	0·016	0·011	0·010	0 041
Totals ...	99·478	99·498	99·774	99·555	99 624	99·697	99·502
Iron	54·40	50·20	52·64	51·90	52·70	60·10	63·92
Phosphorus	0·248	0·227	0·195	0·362	0·355	0·086	0·328

* Magnetic oxide.

Dunderlandsdalen.—The occurrences of iron-ore in the Dunderland valley stretch over a length of about 15 miles, and cover an area at their outcrop of about 1,000,000 square yards. They are, so far as extent is concerned, by far the largest deposits in Scandinavia. It would, however, be beyond the scope of this paper to do more than give a very general description of these enormous deposits, concerning which several books have already been written.

The writer only visited one of the six districts into which the field may be divided, and as his visit was during the winter, he is not able from his own observations to give any full description of the different veins, and is indebted to the publications of Prof. Vogt and others for much of his information.

The deposits commence at Vestraatid, about 16 miles from the innermost end of Ranenfjord, and are possibly a continuation of those at Fuglvik and Ormli. The ore-veins follow the course of the Dunderland river in an easterly and north-easterly direction from Vestraatid to Hatten in the extreme north-east. They occur either within or near a thick layer of limestone, mica-schist and gneiss being also largely present. The strata are usually nearly vertical, the dip tending on the average in a north-easterly direction.

* *Norges Geologiske Undersögelse*, No. 3, Prof. Vogt, "Salten og Ranen."

The iron-ore is found in parallel veins from two to five in number, separated by layers of schist or limestone, and varying in thickness from 2 to 60 feet. Some magnetic iron-ore is found, but the great bulk consists of specular iron-ore, mixed with a little magnetite. It is soft, easily disintegrated, and has a very high lustre. It contains numerous parallel layers of siliceous matter running through it, consisting chiefly of quartz, epidote, calcspar, and some apatite. When freed from the siliceous matter, the ore is very pure, holding usually about 65 per cent. of iron. In large samples, however, the percentage of silica rises rapidly; and as an example of what might be expected from hand-picked ore, worked on a large scale, a sample of some 500 tons, which was sent to Scotland in the summer of 1895, was found to contain only 52 per cent. of iron.

As some 16 to 20 miles of railway would require to be laid in order to bring this ore on the market, it is very doubtful whether such an undertaking would prove remunerative unless some means were adopted to increase the value of the ore, or, in other words, to reduce the percentage of silica.

Owing to the soft nature of the ore, there is little doubt that this could be easily and cheaply done by crushing and washing. In addition to this, it would, however, be necessary to knead the finely-crushed ore into blocks, by mixing it with lime and pressing (the method followed at one time at Norberg in Sweden), or by consolidating it by some other means before it would be suitable for use in the blast-furnace.

If the ore could be worked in this manner, there is no doubt that it would open out a large source of iron-ore supply, which would yield an ore high in iron and possibly (by reason of the washing) low in phosphorus.

The following are some complete analyses of samples of Dunderland ore :—

Samples.	Hæmatitic Iron ore.				Magnetic Iron ore
	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.	No. 4. Per Cent.	No. 5. Per Cent.
Peroxide of iron	82·21	68·03	85·12	85·33	7·58
Magnetic oxide	5·07	4·23	2·96	2·52	69·73
Silica	8·00	20·35	7·10	9·85	13·55
Alumina	1·06	1·79	1·20	0·75	1·22
Protoxide of manganese	0·21	0·27	0·22	0·18	0·46
Lime	2·70	3·80	2·50	1·20	3·90
Magnesia	0·29	0·75	0 46	0·14	2·55
Phosphoric acid	0·121	0·565	0·246	0·128	0·716
Sulphur	0·010	0·025	0·012	0·010	0·023
Totals	99·671	99·81	99·818	100·108	99·729
Iron	61·32	50·68	61·71	61·55	55·89
Phosphorus	0·053	0·248	0·108	0·056	0·314

The writer's opinions may be summarized as follows:—

(1) Two classes of iron-ore are found in Norway, namely, siliceous iron-ore and titaniferous iron-ore (and only the first class is dealt with in this paper).

(2) Siliceous ore is always found near thick limestone, and occurs usually as some form of specular ore mixed with a little magnetite. Fairly large bodies of magnetic ore are sometimes found in connexion with this ore.

(3) Some of these occurrences (such as Fuglstrand, Mösjöen, and Siljelid) are merely iron-impregnated rock, with thin deposits of purer ore enclosed, and are of no industrial value.

(4) Other deposits consist of fairly rich ore, holding veins of siliceous matter. They can seldom be made to produce ore in bulk holding more than 54 per cent. of iron or less than 16 per cent. of silica, when hand-picked in the ordinary way. But probably, by using mechanical appliances, these results could be very much improved upon.

(5) The average content of phosphorus is about 0·25 per cent.; it is too high for steel-making by the acid process, and is too low for making a good basic slag by the basic bessemer process.

(6) In the case of the ores of Næverhaugen and Dunderland, the percentage of phosphorus might possibly be reduced if the ore were crushed and washed.

The Chairman (Mr. T. W. Benson) thought that the general impression to be got from this paper was that Norway was not a rich mineral field, and until the ores of Spain were exhausted, those described in the paper were not likely to prove of value to this country. He understood that the labour laws in Norway were exceptionally favourable to the workmen.

Mr. T. E. Forster asked whether the mines were private property or did the Government own the minerals, and what facilities were given for acquiring them?

Mr. M. Walton Brown (Newcastle-upon-Tyne) understood that if a foreign capitalist started a mine in Norway he was compelled, before he could close it again and remove his plant, to leave an amount of capital to be spent in maintaining the workmen whom he had collected at his mine.

DEPOSITS IN ELVSFJORD.

GEOLOGICAL MAP OF A PART OF NORTHERN NORWAY,

ACCORDING TO THE SURVEY OF

DR. TELLEF DAHLL.

FIG. 1.

REFERENCES.

- CARBONIFEROUS
- DEVONIAN
- CAMBRIAN
- ARCHÆAN
- GRANITE
- IRON-ORE

13° 14° 15°

67° 66°

Scale, 29 Miles to 1 Inch.

BODÖ · SALTENFJORD · SKJERSTADFJORD · SOUTH FOLDEN · NARVIKHAUGEN · SVARTISEN · HATTEN · VESTRANALIDI · FUGLSKIH · DUNGVAND · RANEN FJORD · ELVSFJORD · FUGLSTRAND · HAGGLI · TOMÖ · DONNÆSÖ · JESTENFJORD · MOSJOEN · RÖS VD.

North of England Institute of Mining & Mechanical Engineers Transactions, Vol. 47

IRON-ORE DEPOSITS IN ELVSFJORD.

REFERENCES.

SCHIST. GRANITE. LIMESTONE OR MARBLE. WORKINGS — ADITS • OPEN WORKINGS.

FIG. 2.

N

BROOK SVINAAEN · FUGLSTRAND · SKRAVALAA · ELVSFJORD · HAGGLI · SELJELID

Scale, 1 Mile to 1 Inch.

CONTOUR-LINES ARE SPACED 300 FEET APART.

The Chairman thought a large amount of capital had also to be put aside to meet accidents, for if a workman was injured the mine-owner had to support him for life. The legislators in Norway had evidently anticipated Mr. Chamberlain's Workmen's Compensation Act.

Mr. Gascoigne said there was also a law that after a man had been in one employment continuously for 3 years he could not be discharged.

Mr. Newbigin, in replying to the discussion, stated that the mining law of Norway was evidently framed with the intention of making each mine as far as possible into an independent colony, responsible for the support of its own poor, and it made the owner liable for the maintenance of anyone who had been in his employ continuously for two years or more. At the time this law was passed, there were fewer means of communication than there are at present, and it was doubtless intended to relieve sparsely populated districts from the possibility of having a number of destitute unemployed workmen thrown on them for support; it, therefore, required the owner of the mine to take all these risks, and many of the older mines were working under this liability. Latterly, however, new mines have evaded the law by the very simple process of never employing a man continuously for more than two years, and the law was having the opposite effect to what was intended, for instead of creating self-supporting colonies at each mine, the miners were constantly travelling about from one place to another, and never settled for long in any place.

Within the last three years, a new employers' liability act had been passed, which had this great difference from the one lately passed in this country, in that the government insures the workmen against all accidents and fixes the rate of the premiums to be paid by employers of labour.

In addition to the above burdens, the taxes are rather heavy, there being a state tax upon invested capital and a commune tax (or district rate) upon income.

It will be recognized that there is not much encouragement to private enterprise in mining in Norway, but, on the other hand, these laws have the effect of keeping the cost of labour lower than it would otherwise be.

All minerals in Norway are owned by the state, who permit anyone, of whatever nationality, to search for and obtain licenses to work them, free of royalty, except in the case of the precious metals. The owners of the ground may, however, claim a share of the profits, provided that they also share the expenses of development; and they must, however, give due notice of their intention to do so. The owner of the ground

may also claim compensation for all damage done to his property, and in the case of cultivated land mining-works may only be carried on with his consent.

The taking out of licenses may be divided into three stages: (*a*) the claim to a discovery of a mineral (*skjærpseddel*); (*b*) the claim to the right of working the discovered mineral (*muthingsbrev*); and (*c*) the measurement of the claims previously made (*udmaal*). Licenses (*a*) and (*b*) do not prevent others from taking claims on the same place or working the minerals: and although the first registered discoverer (if he has kept up his claim) has the right of first measurement, yet ownership cannot be fully established until measurement has been obtained. Claims have been made for almost all of the known occurrences of iron-ore, though many of them may not be valid. And these so-called concessions are constantly being offered for sale in this and other countries. Their owners always insist upon a large cash payment before allowing mining work to be begun, in addition to a royalty; and this, to put the most charitable interpretation upon it, shows great lack of confidence of the owners in the value of deposits.

Although the siliceous iron-ores of Norway have many objectionable features, yet in the case of some of the better deposits the defects ultimately reduce themselves to the relative cost of the iron compared to that of other ores, and he thought that, subject to a satisfactory arrangement being made with the owners, British capital might be invested in them with a good prospect of having a reasonable return. Such an arrangement should, he thought, be either a direct partnership with the Norwegian owners or by the payment of royalty only.

With respect to the average content of the Dunderland ore, which he has stated to be 52 per cent. on a cargo of about 500 tons, he had since writing the paper received the following analysis by Mr. Tatlock of Glasgow of the same cargo, which showed a somewhat higher result:—

Analysis of a Sample drawn from a Delivery of 450 tons of Dunderland Iron-ore, from the Steamship *Bergen*, at the Works of The Coltness Iron Company:—

	Per Cent.		Per Cent
Peroxide of iron	77·59	Titanic acid	0·07
Bisulphide of iron	0·03	Sulphuric acid	0·04
Oxide of manganese ...	0·55	Combined water	1·33
Lime	2·88	Moisture	0·05
Magnesia	1·20		
Alumina	0·73	Total	100·003
Silica	14·77		
Phosphoric acid	0·343	Iron	54·33
Carbonic acid	0·42	Sulphur	0·03
		Phosphorus	0·149

Mr. A. L. Steavenson remarked that the ore seemed as though it would be very refractory to smelt. He had pleasure in moving a vote of thanks to Mr. Newbigin for his interesting paper.

The motion was cordially approved.

The following "Memoir of the late Thomas John Bewick" was taken as read :—

MEMOIR OF THE LATE THOMAS JOHN BEWICK.*

By T. BURRELL BEWICK.

Mr. Thomas John Bewick, M. Inst. C.E., F.G.S., was, as his name suggests, a Northumbrian by birth, having been born in 1821 ; he resided for many years in his native county, where he received his education, and was in 1837 articled to the late Mr. Thomas Sopwith, F.R.S., M. Inst. C.E., wellknown in his time as one of the most capable engineers in the North of England. Mr. Bewick's connexion with that gentleman continued for nearly 30 years, during which period he was associated with a large number of mining and other undertakings.

As early as 1842, as also during later years, Mr. Bewick was engaged in making models of coal and lead-mines, illustrative of the geological conditions and characteristics of mineral deposits, and explanatory of the methods of working them. In this particular his work was of a specially noteworthy character in its connexion with the Forest of Dean coal-field, Ebbw Vale and other coal and iron-mines, and the Hudgill Burn and adjacent lead-mines in the North of England.

From the year 1844 to 1846, when this country was in the throes of the railway-mania, Mr. Bewick was employed in laying out several important railway-projects in the North of England and elsewhere. When the excitement consequent on the dawn of the railway-era had subsided, Mr. Bewick accepted an appointment as chief engineer to the W.B. lead-mines, at that time one of the largest undertakings of that description in Northumberland and Durham, and his connexion therewith continued uninterruptedly until the close of 1865, when, on its severance, he was presented by the inhabitants of the district with a handsome service of silver plate, to which Mr. W. B. Beaumont, the owner of the mines, added a silver tea and coffee-service.

It was during Mr. Bewick's connexion with the W.B. lead-mines that the now wellknown hydraulic system of machinery for pumping, winding, crushing, and allied purposes was introduced by Lord (then Mr. W. G.) Armstrong : the whole of this machinery being erected under the direc-

* Mr. T. J. Bewick's portrait forms the Frontispiece of the current volume of the *Transactions*.

tion of Mr. Bewick. It may be mentioned that the mountainous character of the Allendale and Weardale districts largely favoured the application of hydraulic power, and by the arrangement of water-courses, storage and other reservoirs, designed by Mr. Bewick, and carried out under his directions, the power derivable from water stored at a high elevation was utilized with efficiency and economy.

It was while Mr. Bewick held the appointment of engineer at these mines that the celebrated Blackett Level, a tunnel 7 miles in length, driven for the purpose of unwatering the Allendale mines, and exploring the lower portion of that mineral district, was commenced, and much of it completed. This tunnel is one of the most interesting works ever executed in connexion with mining in this country, its course having been determined and the engineering details thereof carried out by Mr. Bewick. In the course of its drivage, and with a view of accelerating its completion, it was attacked at five different points—at four of these by means of vertical shafts, at each of which the pumping of the water and the winding of the material were effected by the utilization of the water flowing down the river Allen, this water being applied after it had been used at the hydraulic and other engines at Allenheads, at the most elevated shaft, and thence flowing through water-courses, to the next succeeding one below, and so on for a distance of 5 to 6 miles. At three of the shafts, the Armstrong accumulator principle was applied, the first motive power being derived from ordinary water-wheels, with suitable machinery for raising the accumulator-weight, and from this accumulator the water was conducted in pipes to the cylinders of the pumping and other engines, having a pressure of 700 lbs. to the square inch.

In 1865, Mr. Bewick became engineer of the Hexham and Allendale railway, a short line constructed with the object of opening up the country between Hexham on the North-eastern railway system and the Allendale district, the latter being the principal seat of the manufacture of all the lead obtained from Mr. W. B. Beaumont's extensive mines at Allenheads and Weardale. This railway was subsequently constructed under Mr. Bewick's directions, and was at a later date absorbed in the main system of the North-eastern Railway Company. From 1866 up to quite a recent period, Mr. Bewick had been continuously engaged in visiting, reporting upon, and advising in connexion with mining properties in this country as well as on the Continent, whilst he was also frequently called upon to give evidence before Parliamentary committees on waterworks, as well as on mining and other arbitrations.

In 1868, Mr. Bewick acquired a lease of the minerals in Langley

Barony, Northumberland, a portion of what, at that time, was known as the Greenwich Hospital estate, extending over an area of many square miles. These he for a time privately developed, and subsequently the enterprise was formed into a limited liability company, several wellknown Northumbrian gentlemen being allied with him in connexion therewith. This undertaking was carried on for many years, under the title of Messrs. Bewick & Partners, Limited, and yielded for a considerable period large returns of lead-ore, being attended, at the same time, with much financial success. The winding, pumping, and dressing machinery in use at these mines was of a most substantial and complete character. The same company established lead-smelting works at Hebburn, near Newcastle-upon-Tyne, which were designed, erected and carried on under Mr. Bewick's supervision.

For many years Mr. Bewick had been wellknown in mining circles in London ; but it was within more recent years that his name became prominently associated with mining ventures, by his joining forces with his old pupil, Mr. C. Algernon Moreing, and establishing a partnership as consulting mining engineers and managers of mines, in London, under the style of Messrs. Bewick & Moreing. At a subsequent period, Mr. Edward Hooper and Mr. T. Burrell Bewick, both old pupils of Mr Bewick, were admitted partners into the firm, which is now known as Messrs. Bewick, Moreing & Co., with branches at Coolgardie and Cue, Western Australia ; Auckland, New Zealand ; and Vancouver, British Columbia.

Mr. Bewick was, in his capacity as mining engineer, a director of several companies, amongst which may be mentioned the Montana Mining Company, Limited, which for many years was most successful ; latterly, however, he withdrew from many of the companies with which he was associated, owing to failing health, and consequent inability to devote adequate time and attention to the work.

At one time he was a Vice-President of the North of England Institute of Mining and Mechanical Engineers, taking an active part until recently in its proceedings.* He supported the scheme for the federation of the mining institutes of Great Britain, which resulted

* He contributed the following papers to the *Transactions* :—

"Mining in the Mountain Limestone of the North of England," vol. xviii., page 163.

"Deep Boring," vol. xx., page 221.

"Lithofracteur," vol. xx., page 222.

"A Project for Supplying Newcastle-upon-Tyne, Gateshead, and other Towns and Villages in Tynedale with Water from the Northumberland Lakes District," vol. xxiv., page 85.

"Notes on Diamond Rock Boring," vol. xxx., page 93.

in the formation, in 1889, of The Federated Institution of Mining Engineers, and for some years was a member of the Council of that Institution. He was a member of the Institution of Civil Engineers, to which position he was elected as far as back 1865, and had been a Fellow of the Geological Society and other kindred institutions for a considerable period. He was also prominently associated with the Newcastle Exhibition of 1887, and was more or less so associated with several of the exhibitions which were held in recent years at South Kensington.

It was not until the beginning of 1897 that he would allow himself to be released from the cares of business, but in the spring of that year, feeling his health failing to such an extent that he was unable to take the same active part therein as that to which he had been accustomed all his life, he reluctantly made up his mind to go into retirement, leaving the conduct of the business of his firm in the hands of the above named partners. It is regretted by his friends that after a period of 60 years of active business life, he should have been spared so short a time to reap the reward of his labours in a well-earned retirement.

Mr. Bewick died at the residence of his son at Putney, on August 29th, 1897, within a few weeks of the completion of his 76th year, and was interred at Haydon Old Church, near Haydon Bridge, Northumberland.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
JUNE 11TH, 1898.

MR. GEO. MAY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on May 28th and that day.

THE LATE SIR GEORGE ELLIOT.

A full-length portrait of the late Sir George Elliot, painted in 1863 by Mr. A. Dever, and presented to the Institute by the present Sir George Elliot, was exhibited.

The PRESIDENT moved that the thanks of the Institute be tendered to the donor.

Mr. THOMAS DOUGLAS seconded the motion, which was unanimously adopted.

ALTERATION OF BYE-LAWS.

The SECRETARY read, on behalf of the Council, proposed alterations in the bye-laws, which will be moved at the Annual General Meeting, to be held on August 6th, 1898.

The SECRETARY read the Balloting List for the election of officers for the year 1898-99.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Sir ARCHIBALD GEIKIE, D.C.L., F.R.S., Director-General of the Geological Survey, 28, Jermyn Street, London, S.W.

MEMBERS—

Mr. DOUGLAS PHILIP BROWN, Mining Engineer, Oakley, Carysfort Road, Boscombe.

Mr. Gervase Cooke, Mining, Civil and Consulting Engineer, No. 1, The Bund, Shanghai, China.

Mr. John Crighton, Mechanical Engineer, Union Iron Works, Stewart Street, Stockport.

Mr. James Andrew Harvey, Consulting Engineer, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne.

Mr. Eugène Kinnaird Haselden, Mining Engineer, Jardines No. 3, La Carolina, Provincia de Jaen, Spain.

Mr. James Kerr Houlgate, Mining Engineer, Balmoral Coal Company, Limited, Balmoral, District Middelburg, South African Republic.

Mr. Robert Embleton Ornsby, Mining Engineer, Seaton Delaval Colliery, Northumberland.

Mr. Andrew James Paterson, Mining and Hydraulic Engineer, Queen Street, Auckland, New Zealand.

Mr. George Anderson Richard, Metallurgical Engineer, Mount Morgan, Queensland, Australia.

Mr. David William Alban Saunders, Civil and Mining Engineer, Worcester Chambers, Swansea.

Mr. Jacob Sharp, Manager, Burnmoor Colliery, Fence Houses.

Mr. Alfred John George Swinney, Mining Engineer, Marmora, Hastings County, Ontario, Canada.

Mr. Sydney Ferris Walker, Electrical Engineer, Cardiff Electrical Works, Severn Road, Cardiff.

Mr. Frederick Napier White, H.M. Inspector of Mines, 9, Mirador Crescent, Swansea.

Associate Members—

Mr. T. W. T. Atherton, Mijnbouw Maatschappij, Bwool, North Celebes.

Mr. Charles William Burn, 28, Fawcett Street, Sunderland.

Mr. George A. Pingstone, 12, Brook Road, Heaton Chapel, near Stockport.

Mr. William Stowell, 3, Akenside Hill, Newcastle-upon-Tyne.

Mr. Frederick Blakeley Yates, 2, Mount Street, Manchester.

Associates—

Mr. Robert Calland, Back-overman, East Hedley Hope Colliery, Tow Law, R.S.O., Co. Durham.

Mr. Vincent Corbett, Mining Assistant, Blackett Colliery, Haltwhistle.

Mr. Francis Ivan Leslie Ditmas, Surveyor, Ferryhill, Co. Durham.

Mr. Thomas S. Hedley, Under-manager, Sherburn Colliery, Durham.

Students—

Mr. William Armstrong, Jun., Mining Student, Cramlington Collieries, Cramlington, Northumberland.

Mr. W. B. S. Leathart, Mining Student, Heworth Colliery, Felling, R.S.O., Co. Durham.

The President delivered the following address :—

PRESIDENTIAL ADDRESS.

By MR. GEORGE MAY.

The Royal Charter, obtained in 1876, records :—

That the Society was not constituted for gain, and that neither its projectors nor members derive, nor have derived, pecuniary profit from its prosperity ; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilating of mines, by ascertaining the conditions under which the safety-lamp may be relied on for security ; that the experiments conducted by the society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions ; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of hauling and working below ground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pit, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "over-winding," have been most successful in lessening the dangers of mining, and in preserving human life : that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of *Transactions* filling many volumes, and forming in itself a highly valuable library of scientific reference, by which the same have been known to the public, and has formed a library of scientific works, and collections of models and apparatus ; and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected ; that, in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's *Transactions*, have led to large and important advantages in the practical knowledge of that subject, and that the Society's researches have tended largely to increased security of life.

Since its foundation in 1852, the Institute has worthily carried out its objects, as stated in the foregoing extract from its Royal Charter. It has always been the forerunner of improvements, and many Acts

of Parliament have been framed upon the results of its deliberations. The saving of life has made marked progress since the formation of the Institute, as shown by Tables I. and II., in a very striking manner.

TABLE I.—PERSONS EMPLOYED, AND NUMBER OF ACCIDENTS FROM DIFFERENT CAUSES IN AND ABOUT THE MINES OF THE UNITED KINGDOM FOR THE YEARS 1852 AND 1897.

Year.	Persons Employed in or about all Mines.			Number of Deaths from Accidents.						
				From Different Causes Underground.					Total at Surface	Gross Total.
	Below-ground.	Above-ground.	Total.	Explosions of Fire-damp or Coal-dust.	Falls of Ground.	In Shafts.	Miscellaneous.	Total Under-Ground.		
1852	177,160	45,683	222,843	264	349	209	116	938	48	986
1897	558,305	136,908	695,213	19	480	57	277	833	97	930

TABLE II.—RATIO OF ANNUAL MORTALITY FROM DIFFERENT CAUSES OF ACCIDENTS IN AND ABOUT THE MINES OF THE UNITED KINGDOM AND THE ISLE OF MAN PER 1,000 PERSONS EMPLOYED FOR 1852 AND 1897.

Year.	Death-rate from Accidents per 1,000 Persons Employed.						
	Employed Underground.					Employed Aboveground from all Causes.	Employed Above and Underground
	Explosions of Fire-damp or Coal-dust.	Falls of Ground.	In Shafts.	Miscellaneous.	All Causes Underground.		
1852 ...	1·490	1·970	1·180	0·655	5·295	1·050	4·425
1897 ...	0·034	0·860	0·102	0·496	1·492	0·708	1·337

It will be seen that the death-rate from accidents per thousand persons has decreased from 5·295 to 1·492 from all causes in the mines, and from 1·050 to 0·708 from all causes on the surface.

I am pleased to congratulate the Institute on its flourishing condition, as evinced by the number of members, graphically shown in the attached diagram. This diagram shows that the membership of the Institute rose steadily from its commencement in 1852 until it attained its maximum in 1877, the year in which the Royal Charter was obtained, with 971 members, and then fell gradually to 1891, when there were only 670 members. It then rose from 1891 to the present time, the membership now being about 1,200.

Papers on topics of local interest appear to have been reserved for meetings of The Federated Institution of Mining Engineers. Many excellent papers, however, have been read on topics connected with

FIG. I.—DIAGRAM PRESENTING THE NUMBERS OF MEMBERS SINCE THE COMMENCEMENT OF THE INSTITUTE IN 1852.

mining in the colonies and in foreign countries, and I venture to hope that some of the younger members will supply further papers on subjects of local interest.

I suggest that instead of annually awarding prizes (as at present) for papers published in the *Transactions* during each year, it would be desirable for the Council to fix on suitable subjects for papers (such as coal-cutting, secondary haulage, transmission of power, or other prominent questions of the day), and to offer substantial prizes for approved papers.

By the extension of opportunities for technical education, mining students of the present day derive considerable advantages from attendance and study at the technical colleges spread over the country, as compared with the meagre opportunities offered to mining students at the birth of the Institute in 1852.

Examinations for granting certificates of competency to colliery-managers were initiated in 1872, and from that year until 1887 one year of attendance at any of the recognized science colleges was permitted to be counted as one of the three years of apprenticeship out of five years of actual underground experience required from candidates. In 1887, however, Parliament withdrew this privilege, and I suggest that The Federated Institution of Mining Engineers should endeavour to have this enactment amended or replaced on its former footing, as the present enactment tends to prevent mining students from attending at technical colleges so long as time so spent is not accepted by the Examination Boards.

The colliery mechanical engineers in the North of England formed an Institute under the title of the North of England Institute of Colliery Engineers, which was carried on for some years with considerable success, and valuable papers were read and discussed at its meetings. That Institute, however, only existed for five years, since which time mechanical engineers have attached themselves to our own Institute.

Both mining and mechanical engineers are eligible as members, and I suggest that steps should be taken to induce mechanical engineers to become members and take an active part in the management and carrying on of the Institute by the reading of papers, etc. Machinery about collieries is nowadays becoming more and more extensive and complicated, and it is essential, therefore, that mechanical engineers should be well informed in all matters affecting their profession.

The formation of The Federated Institution of Mining Engineers has been attended with considerable success, and has materially increased

the facilities for obtaining information by the members, both by the interchange of opinions and by the reading of communications from members at the three meetings held annually in different districts of Great Britain, and by discussions on papers written by members resident in all parts of the world.

The present satisfactory position of the Institution would be materially increased if members used their endeavours to extend its membership, and more especially if those who are members of kindred societies would exert their influence in favour of federation. At the present time this Institution comprises six affiliated societies, representing a total of upwards of 2,500 members.

Since the formation of our Institute in 1852, vast improvements have been made in all branches of mining, as evidenced by the papers printed in the *Transactions;* and some of the principal improvements may be shortly summarized as follows :—

When the Institute was founded, *boring* was carried on in a very crude manner, and very much in the way in which it had been done for many preceding centuries. Since then, various improvements have been made in boring methods, including the diamond system, by which cores of strata and even of coal-seams, are accurately obtained. The Canadian oil-well system has been successfully adopted for boring salt-wells in the county of Durham. And by these and other systems, rapid progress can be made in the boring of deep exploring-holes.

The old systems of *sinking* have been extended for passing through heavy feeders of water by the use of the Kind-Chaudron system, which was successfully employed at Whitburn colliery in this country, and at many other mines on the Continent. The system of freezing water-bearing strata, as introduced by Mr. Poetsch, has also been successfully employed both in Europe and in the United States of America.

In the North of England, and particularly in Northumberland, the longwall *system of working* has made rapid strides of late years, but it has not made so much progress in the sister county of Durham. The rib-and-stall system has been very successfully employed at many Durham collieries of recent years.

Coal-cutting by machinery has not made so much progress in the counties of Durham and Northumberland as in the Midland counties and Scotland, as the system of bord-and-pillar working does not lend itself very successfully to its use. At present, a few collieries have coal-cutting machines in use, actuated by electricity or compressed air. The day,

however, is fast approaching when it will become necessary to work thinner and more expensive coal-seams, and then cutting-machines will be employed more fully, and necessarily the longwall method of working will be adopted.

Of late years, wooden *timbering* in many cases has given way to the use of steel bars and girders, more particularly in the case of main roads, and in some cases for working-places on the longwall system.

The system of *ventilating* mines in vogue when the Institute was founded consisted of either (*a*) carrying the air round the workings, or (*b*) by shething. But now, these methods have all given way to the system of taking the air directly round the working-face and afterwards coursing the air through the older workings.

The furnace system of *producing ventilation* is rapidly disappearing, having been first replaced by slow-running fans of large diameter, driven by wasteful engines. And these installations in turn are now giving way to economical quick-running fans of small diameter driven by engines of economical types as regards steam-consumption.

The lighting of collieries by Davy, Clanny and Stephenson *lamps*, being proved unsafe, they have been replaced by protected or shielded lamps of the Mueseler, Marsaut, and similar types. Electric lamps are in use in limited numbers, but their advantages and economy have not been finally established.

The dangers of the use of blasting-powder in coal-mines are well-known, and after the passing of the Coal-mines Regulation Act of 1887 a demand arose for *explosives* which would be more suitable for use in coal-mines than black powder. "Flameless explosives" were at first adopted with some confidence, but the *Report of the Proceedings of the Explosives Committee* by Mr. A. C. Kayll showed that all high explosives produced evident flame, and that although less liable than blasting-powder to ignite inflammable mixtures of coal-dust, air and fire-damp, they could not be relied upon as ensuring absolute safety in presence of such inflammable mixtures.

Recently the Home Secretary has defined (by an order of Council now in force) the explosives which are "permitted" for use in coal-mines, and also the conditions under which they may be used, and he has thus relieved colliery-managers of responsibility to a limited extent.

Considerable improvements have been effected both in main *haulage* (the bringing of coals from the main haulage-stations to the shaft) and in *secondary haulage* (by which coals are conveyed from the putting-flats to the main haulage-stations). Main-and tail-rope haulage, which was

principally used in the North of England, has of late years been replaced to a very great extent by endless-rope haulage, which appears to be very well suited to the needs of the district. Two good papers on secondary haulage by Mr. Galloway and Messrs. Forster and Simpson have been printed in the *Transactions*; and there no doubt is still room for the adoption of improvements and more economical methods of haulage between the working-face and main-haulage roads. The use of mechanical subsidiary hauling-engines actuated by compressed air, electricity, or other sources of motive power will be generally adopted in course of time.

The *winding-engines* principally used in the North of England were of the vertical lever type, and these have been replaced in modern plants by double-cylindered horizontal-engines of superior type, fitted with automatic expansion-valves adapted for the use of high-pressure steam, whereby more rapid winding is attained. The use of compound winding-engines has not made much progress, but the advantages of their use and of high-pressure steam are now attracting the attention of mechanical engineers.

Formerly water was raised by means of large slow-speed *pumping-engines*, situated on the surface, requiring practically a separate shaft, or a large proportion of the area of the winding-shaft, for the insertion of the pumps, spears, quadrants, etc. This system is now rapidly giving way to the use of smaller high-speed engines and pumps placed near the bottom of the shaft, forcing the water to the surface.

The old-fashioned egg-ended type of cylindrical *boiler* is rapidly giving way to the use of double-flued Lancashire and other types of boilers, which are capable of being more economically worked at higher pressures.

In 1852, it was very common to find uncovered *heapsteads*, but at the present day covered heapsteads are in general use. Gravitation-roads have been very successfully applied both at the top and bottom of the shafts, and have proved capable of being economically worked; they have also enabled the output to be dealt with in an expeditious manner.

Old-fashioned fixed *screens* have of recent years given way to the use of revolving and jigging-screens of various types for the sizing of coal. The *cleaning* of coals was usually very inefficiently effected at the end of the screen, but this system has now given way to the use of movable steel-belts, whereby the cleaning is dealt with in a more efficient manner.

Owing to the working of thin and inferior coal-seams, it has become

necessary to erect *washing-plants* to remove the impurities. Many suitable forms of coal-washers have been introduced, including the Lührig, Robinson, Murton, and others, by which the coal is prepared for the market or for the manufacture of coke.

The beehive *coke-oven* still retains its place as one of the best forms of oven for the making of blast-furnace coke, and with the additional advantage of rapid loading by means of small locomotives running along the tops of the ovens, and the employment of machinery for removing the coke from the oven on to moving belts passing the doors of the oven, it will be a difficult matter to find a more economical system of coke-manufacture. Various systems for the recovery of bye-products from coal in the process of coke-making have been introduced, and many plants have been erected and are being worked at a profit.

At the present time, *compressed air* is the most general system in use for the *transmission of power* underground for the purposes of hauling, pumping, coal-cutting, drilling, etc.

Electricity is making rapid progress as a means for the *transmission of power*, and it is possible that the uncertainties and defects which have been more or less associated with the use of electrical power-machinery may be overcome by the use of multiphase machinery, a pressure of 100 to 500 volts being used for short distances, and up to 10,000 volts for power-transmission over long distances. The members have recently had the opportunity of seeing the first multiphase plant in Great Britain, consisting of two generators developing about 120 horse-power and driving 11 motors ranging from 120 horse-power downwards, whilst an electric-lighting plant is arranged to run in conjunction with the motors.* At Niagara Falls, the electric-power company are prepared to sell power for continuous loads at the rate of £3 12s. per horse-power per annum; and the company can afford to distribute power within a radius of 200 miles at a lower price than it can be generated in the highest class of steam-engines with fuel at 12s. per ton, and they can distribute units of 500 horse-power within a radius of 50 miles and compete under the same conditions. †

Electricity is being very generally employed as a means of *firing shots*, with excellent results, and there is no doubt that either the high or low-tension systems are superior to any other which can be used for the purpose.

Electric bells are now extensively used for *signalling* or engine-planes and in shafts, and the use of electric telephones from the surface to the

* *Trans. Fed. Inst.*, vol. xiv., page 349. † *Ibid.*, page 335.

shaft-bottom and thence along the engine-planes is rapidly extending, and permits of ready communication over long distances.

Electricity has been for some years employed very successfully for the *lighting* of the surface, shaft-bottoms, stables, etc. The lighting of the working-places by portable lamps has already been referred to.

It was supposed until recently that *gas-engines* were only suitable for the production of small power or for intermittent work, but, at the present time, single-cylinder engines are made indicating about 150 horse-power, and double-cylinder engines (single-acting engines) indicating over 200 horse-power, and there are installations of gas-engines working regularly and indicating nearly 1,000 horse-power.

It is only of recent years that mining engineers became of opinion that *coal-dust* was an actual source of danger in coal-mines where blasting was carried on. It is now generally admitted that blasting-powder is capable of igniting coal-dust, but the conditions necessary for such ignition have not yet been determined. The experiments of the Explosives Committee of this Institute have modified the opinion that coal-dust to become dangerous must be present in quantities so large as to preclude the practical working of the mine, and their recent experiments demonstrate that ignitions can be obtained by blasting-powder when less than 1 pound of coal-dust is suspended with air in a space of about 160 cubic feet.

Whilst progress is being made with the *Geological Survey of Great Britain*, and of the Northumberland and Durham coal-field in particular, it is a matter of surprise to find on perusing the reports of the Science and Art Department, South Kensington, that the Director-General of the Geological Survey has been instructed to direct the engineers of his staff to field work and the preparation of the maps, and that the Lords of the Committee of Council on Education have given no instructions for the issue of detailed memoirs, the publication of which would greatly add to the value of the published maps.

Mr. J. B. Simpson had pleasure in proposing a hearty vote of thanks to their President for his interesting address. He had given the members a *résumé* of the progress of mining during the continuance of their Mining Institute, and had placed before them a record of the benefits which this Institute had conferred upon coal-mining generally. Such an address did not require criticism, but there were two points which the members should bear in mind, and endeavour to carry out Mr. May's suggestions.

Members knew (as Mr. May had stated) that one year at a technical college would not stand as part of the five years' pupilage for practical experience in mining. And now that the Government had put upon mining engineers all sorts of regulations, which involved a large amount of technical knowledge, he thought that they should certainly alter the clause in the Coal-mines Regulation Act and allow one or two years at a mining college to stand for part of the five years, and he thought that the coal-owners and the mining institutes generally should make representations to the Home Secretary and endeavour to have this regulation altered.

Another point requiring particular attention was one bearing upon the education of colliery-engineers. He thought that the status of a colliery-engineer should be very much improved. Engineering had now got beyond the days of "rule of thumb." The mechanical appliances about collieries were expensive and intricate, and high-class engineers were required to manage such machinery; and although he made no statement against the present-day mechanical engineer, he thought that for the future there should be some better means of educating the men who were to be placed in charge of the mechanical department of large collieries.

Mr. Thomas Douglas, in seconding the vote of thanks to their President for his address, said that his mind recurred much to the time long ago when mining was in a position different from that in which it was at the present moment. When he went into the mines in 1845, things were very much like what Mr. May had referred to, and therefore he could speak very strongly in reference to the enormous progress that had been made in mining and matters connected with mining since that time. He was not one of those who believed in the saying that the old days were very much better than the present times.

The vote of thanks was very cordially adopted, and briefly acknowledged by the President.

DISCUSSION UPON MR. THOMAS G. LEE'S PAPER ON THE "INTERNAL CORROSION OF WIRE ROPES."*

Mr. W. C. Blackett said that there was one point in connexion with the selection of winding-ropes to which he desired to draw particular attention, and that was the size of the wires used. In the various ropes

* *Trans. Fed. Inst.*, vol. xiv., page 400.

referred to by Mr. Lees in his paper he did not recollect that any particular observation had been made on that question. He had had his attention drawn to it some few years ago, when called upon to give evidence concerning an accident at a neighbouring colliery whereby several lives were lost by the breaking of a winding-rope. He there found that one of two ropes, working side by side in the same shaft, under the same conditions and for the same length of time, had severed owing to internal corrosion invisible on the outside; while the other rope was almost as good as on the day when first put to work. The first rope was "compound," having six strands, each with eight wires (No. 14 Birmingham wire-gauge) round cores made of five wires (No. 17 Birmingham wire-gauge) round one wire (No. 20 Birmingham wire-gauge), the whole having a central hempen core and a total of 84 wires. The second rope had six strands of seven wires and a hempen core and a total of 42 wires. Both were Lang lay, but the former had twice as many wires as the latter. Apart from the relatively larger exposed surface in relation to solid contents of the small wires as compared with the large wires (which, of course, was most important), there was a much greater tendency for moisture to enter among small wires than among large, owing to capillary attraction. And he wished to make the suggestion that, having due regard to flexibility and diameter of drum, etc., it was much better to use a simple laid rope with large wires than a compound rope with many small wires. He thought that attention to this question would prove of more importance than galvanizing, which might possibly at some time prove delusive.

The PRESIDENT said that a similar case had come under his notice, where the rope was used in an upcast shaft, and the moisture produced by exhaust-steam proved very destructive to the wire strands on the inside of the rope, notwithstanding that the outer wires did not suffer any harm. He attributed the damage at the time to the rope not being tight enough and water percolating into the inside of the rope.

Mr. J. H. MERIVALE remarked that many of the members would remember an accident occurring at Shirebrook sinking about a year ago, where a rope broke, after being in use about 9 months. The occurrence was due to internal corrosion; there was not one broken wire outside. Yet the rope had been resocketted only 9 weeks before the accident, and the interior was then in perfect condition. Moreover, a piece of the rope, near the point of fracture, was tested at the Yorkshire College and required a strain of 34 tons to break it, the weight of the loaded kibble

being only 62 cwts. Some engineers were in favour of using galvanized wire, wherever there was any acidity in the water. On the other hand, many engineers, including practical ropemakers, have stated that as the elasticity of steel wire was different from that of zinc, there was a tendency for the zinc to peel off, and a galvanic action was set up which rendered the galvanized rope much more dangerous than an ungalvanized rope.

Mr. J. I. Hopper thought that there could be no doubt that, for winding or hauling, the larger the wire the longer the rope would wear, provided the machinery was capable of carrying the larger size of wire, otherwise it was very much a question of flexibility. He would only recommend the use of galvanized wire in case of absolute necessity, as galvanizing had two effects, it reduced both the breaking-strain of the wire and the torsion. In his experience, a galvanized wire always had a tendency to turn brittle, and he would recommend the avoidance of its use whenever possible.

Mr. J. H. Merivale said that since the Shirebrook accident he had put caps on the pulleys, to prevent moisture from getting amongst the wires where the rope was open from bending over the pulley.

Mr. W. C. Blackett said that the only broken ropes he had seen were compound ropes such as those to which he had referred.

Mr. W. H. Wood said that the size of the wire interfered greatly with the flexibility of the rope, and this must be taken into consideration before they decided to adopt the largest possible wire.

Mr. T. G. Lees, replying to the questions, wrote that, although no particular attention had been called by him in his paper to the thickness of the wires that were generally used in the construction of winding and hauling ropes, it was a point that had always been recognized and carefully considered in ordering ropes for wet shafts Judging from his experience the wire should be as large as possible, consistent with its proper working around the pulleys, etc. The large wire presents a greater wearing surface, but, as compared with an increased number of smaller wires, there is relatively less surface exposed to the action of corrosion. This is, no doubt, a most important point, and the writer agreed with Mr. Blackett that more attention should be paid to it ; but, at the same time, the question of galvanizing the wires is of equal, if not of greater, importance where bad water is present in the shafts. The use of galvanized wires appears to be new to many colliery managers, although

galvanized winding ropes have been in use for more than 20 years, and there seems to be a fear that galvanizing would injure the wires. The only reply the writer could give to this was that for the past 15 years all the winding and hauling ropes used at Clifton colliery had been galvanized, and no others will be used in future. The winding-ropes working in shafts where bad water is wound every night, work from 3 to 4 years, and are quite free from corrosion at the end of that time, whereas plain wire ropes only last from 9 to 18 months. Under ordinary working conditions, there is no tendency for the galvanizing to peel off as mentioned by Mr. Merivale, and the fact that the ropes lasted so long, and were in such good condition when taken off, should satisfy the most sceptical.

With reference to Mr. Hopper's remarks as to galvanizing reducing the breaking-strain of the wires, and causing them to turn brittle. If the loss be about 2 per cent. in the strength of the galvanized wire when new, but the ropes last twice as long as ropes made of plain wires, and were free from corrosion at the end of the time, the writer thought that the safest and most economical way would be to accept the trifling loss, which could easily be made up by having a slightly stronger wire: not that this was necessary, as a sufficient margin should always be allowed between the working-load and the breaking-strain when the ropes are new. As to the galvanized wires becoming brittle, that is a common tendency in all wire ropes running over iron pulleys; ropes do not often break from the hardness of the wires, but generally through corrosion. Covering the pit-head pulleys would keep off the rain, but that is of less consequence than the acid waters in the shafts.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

AMIANTHUS-DEPOSITS OF VALLE MALENCO, ITALY.

Prime Contribuzioni allo Studio dei Giacimenti di Amianto della Valle Malenco. By Luigi Brugnatelli. *Rivista di Mineralogia e Cristallografia italiana, vol. xviii., pages* 44-54, *with a figure in the text, Padua,* 1898.

The author, in the first place, describes a hydrated carbonate of magnesia, which he regards as probably a new mineral, associated with the amianthus-bearing rock. The specific gravity is 2·013, the chemical composition is :— $MgO = 43{\cdot}32$, $CO_2 = 21{\cdot}85$, $H_2O = 34{\cdot}32$, and the author considers that the most probable chemical formula for the mineral is :— $Mg_2(HO)_2CO_3 + 3H_2O$. It occurs in extremely slender shining prisms, grouped in bundles intricately dovetailing into each other.

On a specimen of amianthus found at Lanzada, the white and slightly yellowish fibres of which are cemented together by magnesium carbonate, forming a sort of felt not unlike so called "mountain paper," crystals of magnesite, dolomite, and aragonite occur. With these are also associated minute crystals of titaniferous magnetite. The author points out the importance of the association of the three former minerals, especially also the fact that the carbonate of lime is in the aragonite condition, as this may serve to throw light on the mode of formation of the amianthus. He thinks it is demonstrable that the deposit was formed from the chrysotile variety of serpentine. L. L. B.

SYZRAN-PECHERSKOYÉ ASPHALT-DEPOSITS, RUSSIA.

Voyage géologique par la Volga de Kazan à Tzaritzyn. By A. P. Pavlow. *Congrès géologique international : Guide des Excursions, No. XX., pages* 22-25, *with figure in text,* 1897.

These are worked on the right bank of the Volga, between Kashpur and Syzran, in the brecciated Permian limestone at one locality ; and in Carboniferous limestone at another locality, lower down the river. The scarcity or abundance of fossils, and the age of the rocks appear to have no connexion with the presence of the bitumen, for it is found also in Lower Callovian sands, which rest unconformably upon the Palæozoic limestones on the north of the Samara peninsula. The bitumen impregnates the mass of the limestone, and occurs in little accumulations and venules throughout the Carboniferous and Permian rocks in this area. It evidently percolated into the rocks from some external source, and spread through them more or less, according to their structure and permeability. As naphtha has been found on the left bank of the Volga, in the prolongation of the Jeguli Hills, that is, on the same line of dislocation as the bitumen-deposits, the author is inclined to believe that both asphalt and naphtha originally welled up from great depths through the fissures resulting from the dislocation.

[It may be added that, as regards means of transport, the asphalt-mines are exceptionally well situated, being in close proximity both to the great river Volga and to the Trans-Siberian railway.] L. L. B.

BERESOWITE, A NEW MINERAL.

Bérésowite, un nouveau minéral de Bérésowsk en Oural. By J. Samsilow. *Bulletin de la Société Impériale des Naturalistes de Moscou*, 1897, *pages* 290-291.

This mineral occurs in small flakes, but never in distinct crystals, is of a dark red colour, has perfect cleavage, and a specific gravity of 6·69. Three analyses were made, and show percentages of lead oxide varying from 79·24 to 79·36, of chromic acid 17·93, and carbon dioxide 2·46, whence the author derives the chemical formula: $2PbO, 3PbCrO_4, PbCO_3$. When the mineral is found in association with galena it is always separated from the latter by a layer of cerussite. Beresowite also occurs in pseudomorphs after crocoïte. L. L. B.

THE GROTTAU BROWN-COAL DEPOSIT, NORTH BOHEMIA.

Die Grottauer Braunkohlenablagerung in Nordböhmen. By Dr. Friedrich Katzer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 561-564.

This little known field is situated in the valley of the Neisse, near Grottau. The deposit belongs to the older Miocene period, and forms an offshoot from the great Zittau basin. At the present time, it is worked by means of the Franz and the Christianen shafts, the former of which is 102 feet (31 metres) deep, whilst the latter does not go lower than 62 feet (18·9 metres). The Franz shaft traverses 19 seams of coal, most of them less than 40 inches (1 metre) in thickness, though there is one seam 25 feet (7·7 metres) thick; and the entire thickness of coal exceeds 50 feet (15½ metres), of which 31 feet (9·55 metres) is worked as the main seam. In the second shaft there are 10 seams of coal, 4 of which average 40 to 48 inches (1·00 to 1·20 metres) each, and the remainder range between 20 and 36 inches (0·5 to 0·9 metre), the total thickness of coal being 28 feet (8·75 metres).

The deposit constitutes a semi-basin, the western portion (Franz shaft) of which is more extensive than the other, and is in a less disturbed condition, the coal-strata being nearly horizontal and almost free from faults; whereas in the eastern section (Christianen shaft) faults and distortions are frequent, and the stratification is broken up to a considerable extent. Many of the faults are open for a width of 20 inches and a depth of 16 to 20 feet (5 to 6 metres), and the walls are covered with effloresced sulphates derived from the pyrites associated with the coal.

The coal is of a brownish colour, and contains a number of stems and other remains of fossilized wood, as also occasional clusters of soft dark coal apparently derived from soft vegetable matter. It can be readily ignited, and burns with a bright though smoky flame. The specific gravity averages 1·163; calorific power (Berthelot) 3·972 calories; and the chemical composition of the coal when dried at 110 Cent. is: carbon, 53·22; hydrogen, 5·56; ash, 3·27; oxygen, nitrogen, etc., 37·95. In its natural state the coal contains about 55 per cent. of moisture, and as it retains this somewhat tenaciously, it is generally sold by measure. The presence of sulphur—as much as 3·8 per cent.—lowers the value of this coal for domestic use.

Owing to the distortions of the seams, mining is rather difficult, especially in the Christianen shaft, and the amount of coal often falls as low as 10 per cent. of the total quantity of matter raised. Pit fires—due either to spontaneous ignition brought about by the oxidation of pyrites, or to direct absorption of oxygen by the coal—are frequent, but bricking up the burning portions is of little use, the best remedy being to bring about a fall.

Four grades of coal are sorted: flat blocks up to 40 inches square; middles—lumps about 20 inches in diameter; nubbles up to 4 inches; and siftings. The dust is used up at the mine. The total output, amounting to some 725,000 bushels (300,000 hectolitres) per annum, meets with a ready sale, so that the coal is not exposed to the deterioration (desiccation) consequent on prolonged storage. To save the expense of packing the seams, the owners prefer to buy the land and allow the surface to subside as the seams are worked out. C. S.

THE DONETZ BASIN, RUSSIA.

Le Bassin du Donetz. By Th. Tschernyschew *and* L. Loutouguin. *Congrès géologique international: Guide des Excursions, No. XVI., pages* 1-55, *with figures in the text and* 2 *plates*, 1897.

The area to which this name is generally understood to apply is that portion of Southern Russia which is overspread by Carboniferous deposits of the littoral type, presenting frequent changes of facies in the vertical succession, and containing coal-seams. Hitherto mining operations have been more particularly concentrated on the western part of this area; its greatest length is about 240 miles from east to west, and its greatest breadth about 100 miles from north to south. On the south-west the area touches the vast sheet of granite of the districts of Berdiansk and Mariupol. The base of the Carboniferous deposits is made up of a series of Upper Devonian felspathic grits, conglomerates, and quartzites, with green and red clay-slates and porphyritic breccias. The last-named are intimately connected with a great mass of porphyry, which separates the above-mentioned rocks from a series of dark-grey limestones and shales. Very detailed descriptive sections of the Carboniferous strata are given by the authors, commencing with the barren Lower Carboniferous Limestones. Above these come micaceous grits, in which thin coal-seams begin to make their appearance. These are succeeded by shales, grits again, and limestones. One of the features of the Carboniferous group in the Donetz basin is the frequent intercalation of limestones among the grits and shales; it is true that the calcareous beds are not of great thickness, rarely attaining 25 feet, but they show a remarkable constancy in the general characters and fauna of each horizon over a large area. The result is that the coal-seams of the Donetz basin are in every locality easily recognized and correlated with those of other localities, with a precision and ease scarcely paralleled elsewhere in Europe. It seems as if the Donetz had been the south-western gulf of a vast Palæozoic sea wherein the Carboniferous sediments were laid down.

The Middle Carboniferous group begins with a succession of sandstones, shales, and dark-brown and light-grey limestones. Above these comes a coal-bearing series, but the seams are seldom thick enough to repay working. Then follows a rapid alternation of shales, limestones, and sandstones, amid which are coal-seams varying in thickness from 1 to 3 feet, seldom thicker. They are very actively worked in the Kalmius river-basin, where the so-called Smolianinovsky group yields coking coal, gas coal, and semi-anthracitic coal. Then there is the anthracitic Bokovskaia group, the coals of which are generally semi-anthracites, less frequently pure anthracites. The coal is found to become a coking coal in certain areas where the continuous outcrop of Coal-measures comes into contact with the Cretaceous strata. At Uspenskoye is worked the Yonovskaia group, which includes no less than eight workable seams.

Above these comes a series of strata about 1,100 feet thick, with many thin seams, but scarcely one that is workable. This is overlain by another 1,000 feet of shales, limestones, etc., much richer in coal, with seams, one of which is about

40 inches thick. The sixth division, in ascending order, of the Middle Carboniferous, that is, its uppermost portion, is about 1,000 feet thick at the typical locality, Lissichansk. The number of coal-seams and the relation of their total thickness to that of the associated rocks are such as to make this division the most profitable to work in the whole series. The seams vary from 10 inches to 6 feet or more in thickness.

The Upper Carboniferous group is about 7,000 feet thick, and workable coal-seams are found only in its lower portion. The succession is again one of limestones, shales, and sandstones many times repeated (lithologically). The uppermost strata are clay-slates, with concretions of argillaceous sphærosiderite resting upon a thin, light-grey, highly fossiliferous limestone.

Folding and faulting are observed throughout the area; indeed, the only strata which do not appear to have been dislocated are the Tertiaries. In the northern part of the basin, near the contact with the Cretaceous, the folds in the Carboniferous are smaller, but sharper, and more complicated by faults than elsewhere. Mining operations have also revealed much evidence of thrust-planes. The authors believe the coal to be of drift origin, and not derived from the decay of vegetation *in situ*, as in so many instances the roof of the seams is formed of shale or limestone containing an abundant marine fauna.

Other minerals of industrial importance, besides coal, occur in the Carboniferous of the Donetz basin—such as gold, mercury, silver, zinc, lead, and iron.

The auriferous deposits, discovered only in 1893, are in the territory of the Don Cossacks, along the Nagolny-Kriaj hills. Here micaceous grits of varying thickness alternate with grey clay-slates, they show distinct anticlinal folding, and are traversed by a series of nearly vertical parallel quartz-reefs, ranging from a few inches to 10 feet in thickness. In the portion nearest the surface, native gold is found, diminishes in quantity lower down, then increases again deep down in conjunction with a ferruginous so-called "chalcedony." The reefs are largely mineralized with brown iron-ore and pyrites, and contain a few inclusions of galena and blende. Working in these deposits is still in the preliminary stage.

Along the same hill-range are grouped the silver, zinc, and lead-mines. A great many were shut down after a few years' unsuccessful working, but in 1890 that of Nagolnaia was re-opened, and a large mine was started near Nagolchik. The rocks are, in every respect, analogous to the auriferous country-rock.

The iron ores are associated exclusively with limestones which crop out on the surface, and down to a depth of about 30 feet, the limestone is found to have passed into a brown spathose ore. But, both as regards quantity and quality, this ore offers little prospect of playing any considerable part in the rapidly developing industries of Southern Russia.

At Nikitovka, on the Kursk-Kharkov-Azov Railway, are the cinnabar-deposits discovered in 1879. The ore occurs in grits and quartzites, much fissured and faulted. If a transverse section be taken of a metalliferous reef, the ore is found distributed in an irregular network, corresponding to the number of fissures which traverse the grit and quartzite. Among the latter are intercalated blocks of coal, within which are found well-formed crystals of cinnabar. It would appear as if the coal had acted as a "concentrator" of the metalliferous substances. The ore must have been deposited from solutions percolating through the fissures in the rocks. A detailed description is given of the tectonic structure, as seen in the mine: there are several shafts here, and levels are mentioned of 120 feet or more below ground.

The Carboniferous series is succeeded by Permo-Carboniferous shales, limestones, and red and green sandstones containing here and there copper ore. Above

these come the dolomites of the Lower Permian. Now, at Bakhmut, these dolomites rest on yellowish-grey clays and marls which contain deposits of gypsum, anhydrite, and rock-salt. In 1874, borings carried down to a depth of 660 feet proved nine beds of salt, of a total thickness of 300 feet. Hereabouts was opened the Briantzevka mine, worked by a French company nowadays: its broad galleries are lighted by electricity. Other mines are the Novaia Velichka, Charlamovka, Peter the Great, etc. The yearly salt production now reaches 258,000 tons (16,000,000 pouds) or more, and is one of the most important industrial features of the Donetz district. L. L. B.

TKWIBULI COAL-FIELD, CAUCASUS.

Excursion à Tkwibouli. *By* S. Simonowich. *Congrès géologique international: Guide des Excursions, No. XXVa, pages* 1-5, *with figures in the text,* 1897.

This short paper is preceded by a complete bibliography of the subject, and the lie of the strata is shown in four horizontal sections. On the northern slope of the Lagori ridge, at 1,500 feet above sea-level, the Tkwibuli river, flowing in many places over outcrops of coal, divides into two branches, which disappear for a time underground in the Cretaceous limestones. After a subterranean course of about 3 miles they reappear on the other side of the escarpment, and continue their course under different names into the plain of Colchis. In the lower part of this river-basin, beneath the Cretaceous limestone appear variegated clays, and these in turn are underlain by sandstones containing *Pecopteris exilis* and coal-seams. Near the village of Kursebi are two seams divided by a micaceous grit, dipping 12 degrees south-west. The lower seam is the thinner of the two; the upper proved at a depth of 70 feet, is 30 inches thick. It yields a fairly compact, non-caking coal; this shows on analysis:—

Coke, 74·70 per cent.	Carbon, 38·30 per cent.	Water,	5·40 per cent.
	Ash, 35·75 ,,	Volatile matter, 20·55	,,

Below the coal-bearing sandstones comes a great thickness of Liassic shales, which form the central part of the basin. These are much folded, and form at the foot of the Nakeral Mountain the base of the coal-deposit proper of Tkwibuli. Here the total thickness of the coal-seams, and intercalated grits and carbonaceous shales, is about 65 feet. Tho following analysis of the Tkwibuli coal is quoted from Prof. E. Favre:—Water, 1·9 per cent., ash, 8·5 per cent., and calories, 62·4. The Lias and the coal-bearing beds dipping northward, disappear under the Nakeral Mountain. It is said that spathose iron-ore was at one time worked within the mass of the coal itself, in the Lamchreli or Kedur area. The plants found in the coal-bearing beds are of Stonesfield Slate (Oolitic) age. L. L. B.

COAL-FIELDS AND IRON ORES OF SHANTUNG, CHINA.

Der geologische Bau von Schantung (Kiautschou), mit besonderer Berücksichtigung der nutzbaren Lagerstätten. *By* Ferdinand von Richthofen. *Zeitschrift für praktische Geologie,* 1898, *pages* 73-84, *with maps and sections in the text.*

The distinguished Under-secretary for Colonial Affairs of the German Empire, the author of this paper, is wellknown for his travels in the Chinese Empire and for the great book and atlas in which he embodied the results of his observations. No person, therefore, was better qualified to point out to the German people the economic advantages and the mineral wealth of their new colony at Kiaochau.

The mountainous, deep bayed peninsula of Shantung is divided by a fault-line running north and south, and sensibly parallel with the course of the Wei Ho, into two geologically and orographically distinct parts. In the eastern region, a broad area of depression stretches from Kiaochau Bay away to the northern coast of the peninsula. It is a fertile, undulating, thickly populated country, with a soil not alluvial, but made up of decomposed rock *in situ*.

The westernmost half of the province of Shantung belongs to the Great Plain of China, and is covered by fluviatile deposits from the Hoang Ho and other rivers and by wind-blown loess.

In Northern China, all the Palæozoic strata, from the Cambrian upwards, lie undisturbed, whereas in Southern China all these, the Carboniferous included, are bent up into folds. Now, Shantung partakes of the northern type. On a rock-base of ancient gneisses and granites are superposed crystalline schists and limestones, 10,000 to 15,000 feet in thickness. Great denudation in pre-Cambrian times has reduced these outcrops to mere sporadic patches, and the ores associated with them have given rise to many delusive hopes. Galena and copper-ores were observed among these rocks by the author, but not in paying quantities.

Talc and steatite occur in the crystalline limestone, and the last-named mineral is largely worked for ornaments and images. The highly-disturbed quartzites and sandstone of Changshan in Western Shantung belong doubtless to the Upper Archæan Wutai series: they are overlain by undisturbed Cambrian.

A characteristic occurrence in Eastern Shantung is the rapakivi-like "Korea granite," which forms whole hill-ranges; it is much veined by pegmatite and quartz, the former of which is rich in tourmaline.

Upon the folded Archæan rest the equivalents of the Cambrian, the middle portion of which is especially developed in Shantung. These middle Cambrians consist of quartz-sandstones, red clay-slates, and siliceous limestones. The "globulitic limestones," full of little dark ferruginous spherules, probably of organic origin, furnish a good building-stone. Above these come again red clay-slates, followed by the Carboniferous series, without any intercalation of Silurian or Devonian.

The Carboniferous Limestone forms here the lowest member of the system. It is overlain by argillaceous and arenaceous rocks, with the uppermost of which are associated porphyries and porphyry-tuffs (probably of Permian age). These in Shantung are immediately followed by loess: Tertiary and Mesozoic strata being conspicuous by their absence.

The coal-fields are restricted to the eastern side of the fault-line already mentioned: they contain several seams of good quality and workable thickness. In part, the Coal-measures are interbedded with Carboniferous Limestone and clastic rocks, in part with the latter alone, and in part, too, with rocks which appear to be of a later age than Carboniferous. Going from west to east, the most important coal-fields are those of:

(1) *Po-Shan.*—Very extensively worked. In quantity and quality of coal, and in the great industrial demand for the mineral, this field takes the first place. On the northern edge of the hill-range, is situated the busy chief town of the district: glass-ware, pottery, enamel-glaze, and paints are manufactured here. The Hi Shan or Black Mountain, south of the town, is the mining centre of this region; and the two chief pits (near the pottery village of Kutawan), are worked by circular shafts, 15 feet in diameter, and respectively 200 and 260 feet deep. The lower shaft is very wet, and here, haulage is done by mules. In the upper shaft, it is done by a windlass worked by 12 to 15 men. The coal is loaded into bags

of oxhide, and the production is said to have averaged at one time 60 to 80 tons per day. The seams vary between 6 and 8 feet in thickness. Timber is the one great desideratum in this district.

(2) *Chang Kiu.*—This coal-field lies 30 miles east of the provincial capital Tsi Nan Fu, and the same distance north-west of Po-Shan. Seams 4 and 6 feet in thickness were worked here at one time, and the author thinks that boring operations would reveal extensive deposits of workable coal.

(3) *Wei Hsien.*—The locality of this name is an ancient commercial centre for Northern Shantung and the meeting-point of many routes of traffic. Its importance may be expected to increase concurrently with the development of Kiaochau.

The coal-outcrops lie south of the city in a sort of "bay" that cuts into the mountain-chain: east and west are volcanic tuffs which probably mark a further extension of the Coal-measures: the strata dip gently northward.

The last mine worked in this neighbourhood was shut down because of the difficulty found in contending with the water: the seam 3 to 4 feet thick was worked by a shaft about 150 feet deep. About 1,000 tons of coal lay on the pit-heap, not coking, somewhat pyritous in character. There are many other abandoned shafts round about, and three seams have been traced at different levels. Much small coal and dust was got, due perhaps to the shallowness of the workings. The low angle of dip and the number of the seams promise a rich reward to those who will undertake deep-level mining.

(4) *I Chu Fu and I Hsien.*—These coal-fields, in contradistinction to the others so far mentioned, lie on the south side of the chief mountain-range. Excellent coking coal is found in association with Carboniferous Limestone and shales rich in hæmatite; coal-seams occur at seven points in the horizontal section described in detail by the author, and iron ore at three points. This is probably due to repetition of the strata by faulting. Workings have not been carried on at deep levels, on account of the inflow of water. A mandarin persuaded a European engineer to set up pumping apparatus at one locality, but the pipes were ordered of too small a diameter, and, moreover, the mandarin committed suicide when the victorious Japanese marched into Wei-hai-Wei. European methods of deep-level working can alone place this district in its true position, in the forefront of the mining industry of Shantung.

The iron ores (red and brown hæmatite) are not worked. All the raw iron needed is brought from the province of Shan Si, and is smelted together with scrap iron in the foundries of Shantung, producing an excellent metal.

Magnetite, due to contact-metamorphism by diorite-dykes and sills, is found in association with crystalline limestone, epidote and felspar-rocks east of Tsi Nan Fu.

The author concludes with a long panegyric of the favourable situation of Kiaochau, especially as the starting-point of railways into the interior, and as a shipping-harbour for the chief coal-fields of China. L. L. B.

PRODUCTION OF ALCOHOL FROM THE GASES OF COKE-OVENS.

Ueber die Gewinnung von Alkohol aus Koksofengasen. Anon. *Glückauf*, 1897, *vol. xxxiii., page* 800.

Dr. P. Fritzsche (*Chem. Ind.*, vol. xx., pages 226-271) has experimented upon the production of alcohol from the ethane contained in the gases given off from coke-ovens, in accordance with the method of Prof. Faraday and Prof. Hennel, which consists in treating ethane with sulphuric acid and water.

Coke-oven gases contain 1 to 1·8 per cent. of ethane, and the writer found that this could readily be absorbed by sulphuric acid upon a working scale, and that the apparatus required would be no larger than that used for absorbing benzol from these gases. To produce 1 gallon of alcohol—4·85 lbs. of ethyl-sulphuric acid 35 lbs. of concentrated sulphuric acid, and 50 lbs. of water are required. The removal of ethylene, after the benzol has been got rid of, presents no difficulties. Of the 45 lbs. of concentrated sulphuric acid required to produce 1 gallon of alcohol, 40 are returned to the next operation.

At the present uncommonly low prices of alcohol, it is doubtful whether this method of manufacturing it would pay. H. L.

DETERMINATION OF SULPHUR IN COAL AND COKE.

Ueber die Menge von Schwefel, die beim Vercoaksen von Kohlen im Coaks verbleibt und die Menge von Schwefel, die bei diesem Processe entweicht. *By* C. v. John. *Verhandlungen der k.k. geologischen Reichsanstalt, Vienna,* 1897, *pages* 134-137.

The author examined several varieties of coal with a view to determining the part played by sulphur in the process of coking. He began with an ordinary analysis of the coal, wherein, besides determining the percentage of water and ash, the calorific power was determined according to the Berthier method. He admits that the Berthier test can hardly be termed scientific, and that it can only yield approximate results ; but he points out that, when applied under similar conditions to different coals, this test is valuable for purposes of comparison.

The sulphur in the coal was determined according to the Eschka method, as amended by Prof. Fresenius. This consists in ignition with a mixture composed of 2 parts of caustic magnesia and 1 part of sodium carbonate, the argillaceous material being extracted with hot water to which a solution of bromine was added till the liquid assumed a pale yellow tinge. This was then poured through a filter, and the sulphur (precipitated by means of barium chloride) was ultimately estimated as barium sulphate, the filtrate having been previously treated with hydrochloric acid and boiled till the whole of the bromine was eliminated.

The amount of sulphur thus found is the total amount present in the coal, and this the author, for convenience, terms the "total sulphur." Exactly the same method was followed for determining the amount of sulphur present in the coke : moreover, the quantity of sulphur left in the ash, both of coal and coke, was determined. The difference between the "total sulphur" and the proportion of sulphur present in the ash represents the amount of combustible or so-called "injurious sulphur." In some cases, the last-named was determined direct by burning the coal or coke in a stream of oxygen, and passing the products of combustion through bromium hydrochloride. This and the tarry products of distillation absorbed all the sulphur given off on combustion. The results obtained by the foregoing direct method invariably coincided with those calculated from the difference between "total sulphur" and "ash sulphur."

In order to institute a direct comparison between the "total sulphur" in a given coal, and that in the coke produced from it, a percentage of the sulphur in the coal was calculated corresponding to the percentage of the coke produced. By this means it was easy to see how much sulphur was got rid of in the process of coking. Also, the percentage of combustible sulphur in the coal and the percentage of combustible sulphur in the coke got from 100 parts of the same coal were determined.

An elaborate table of results accompanies the paper, from which it is seen that the geologically older coals lose less sulphur in coking than the brown coals. The presence of pyrites as such was proved in very few coals: in most case, especially in the brown coals, sulphur occurred in the form of organic compounds. No general law as to the ash-sulphur can be deduced from the results.

Ten of the coals examined were from various Coal-measure localities in Austro-Hungary; one was from the British Coal-measures; seven were Tertiary (brown) coals from Austria, Rumania, etc., and one was a specimen of recent peat. The percentage of "total sulphur" in coal varied from 0·19 to 8·84; in coke from 0·26 to 7·25; of sulphur in coal-ash, from 0·01 to 1·49, in coke-ash from 0·01 to 2·05; of "combustible" or "injurious sulphur" in coal from 0·18 to 7·77, in coke from 0·05 to 4·08. The percentage of "injurious sulphur" got rid of in the coking process varied from 22·58 to 72·22. L. L. B.

QUANTITATIVE ANALYSIS OF COMMERCIAL COPPER.

Ueber die Quantitative Analyse des Werk-Kupfers. By E. Murman. *Monatsheft für Chemie*, 1896, *vol. xvii., pages* 697-731.

The Sub-Sulphide Method.—The copper (1·2 to 1·5 grammes) being dissolved in dilute warm nitric acid, a few drops of hydrochloric acid, and sulphuric acid in excess, are added, and the solution evaporated to drive off the nitric acid, the silver and lead precipitated being then filtered off and washed with acidified (H_2SO_4) water, and the copper thrown down as sub-sulphide. If a little sulphuretted hydrogen be mixed with the hydrogen employed for the ignition-process, the time-limit and temperature of the operation are less restricted than when pure hydrogen is used, but the results are higher unless a bright red heat is maintained all the time. The best method is to employ pure hydrogen for the first quarter of an hour, repeating the heating until constant weight is obtained, and finally adding a little sulphur and heating up again to a dark-red heat.

To free the sulphide precipitate from alkalis (in the reagents), it should be heated in an air-oven, and washed with dilute sulphuretted-hydrogen solution before heating to redness. Lime is more difficult to get rid of, but this impurity is of almost inappreciable amount. Silica is left behind on dissolving the precipitate in nitric acid after weighing.

The electrolytic determination is hardly reliable, owing to the variations (3 to 4 milligrammes) in the weighing of the platinum basin, and to the presence of water. This may be avoided by heating to redness, which, however, causes inconvenience from the formation of copper-platinum alloy at the plane of contact.

Oxygen.—The sample is freed from fat by the aid of a solvent, and then dried and brightened with a cloth and some clean sand. After weighing, the metal is heated in an atmosphere of hydrogen in a tube 10 inches (25 centimetres) long, $\frac{2}{5}$ to $\frac{1}{2}$ inch (10 to 12 millimetres) in diameter, with a strong bulb 2 inches (5 centimetres in diameter), for between one and two hours (according to the thickness of the sample cuttings) at a bright red heat, and afterwards for a further half hour, the oxygen being determined by the loss in weight sustained by the copper.

Lead.—The cold solution of the metal in nitric or sulphuric acid is treated with a little sulphuretted hydrogen, all the lead being precipitated along with the first copper thrown down; by dissolving the precipitate in nitric acid and subjecting it to electrolysis the lead is separated from the accompanying copper. This method is much more delicate than precipitation as sulphate.

Arsenic and Antimony.—A large sample is heated in hydrogen for over two hours at a bright red heat, the upper part of the bulb being capped with asbestos to prevent condensation of the antimony. This will, however, take place to some extent in the tube, the greatest portion being arrested by passing through hydrochloric acid and bromine. In weighing the antimony as oxide, the alkalis should be dissolved out by water after the first heating, and since the oxide volatilizes at red heat only in a reducing atmosphere, air should be admitted to the crucible during the ignition.

Cuprous oxide, if present in quantity, is determined by the argentic nitrate method, though this is not sufficiently accurate to be used when the percentage is small. C. S.

ELECTROLYTIC ANALYSIS OF COPPER FOR TECHNICAL PURPOSES: ESTIMATION OF ARSENIC, ANTIMONY, SULPHUR, ETC.

Analyse du Cuivre industriel par Voie électrolytique. By A. Hollard. *Comptes rendus de l'Académie des Sciences*, 1896, *vol. cxxiii., pages* 1063-1065.

Estimation of Arsenic and Antimony.—The residual liquor from the electrolytic deposition of the copper is evaporated to near dryness, taken up with 1 to 2 cubic centimetres of hydrochloric acid, and made up to 200 cubic centimetres, being then treated with hydrogen sulphide at an initial temperature of 70° to 75° Cent. until cold, and filtered at the end of 24 hours. The precipitate, which consists of arsenic, antimony, a little lead, and possibly copper, is washed with hydrogen sulphide solution, and treated with ammonium sulphide and filtered, the solution being evaporated to dryness, warmed with hydrochloric acid and potassium chlorate, and treated with ammonia and magnesia mixture to throw down the arsenic, which is re-dissolved in acid and precipitated once more by ammonia. Antimony is thrown down from the acidified ammoniacal liquor as sulphide, and re-dissolved in strong alkaline sodium sulphide, to be finally deposited by means of a 0·18 ampère current, the volume of liquid not to exceed 80 cubic centimetres, on account of the small quantity of antimony present.

Estimation of Nickel, Cobalt, and Iron.—The filtrate is heated to drive off hydrogen sulphide, the iron being peroxidized by nitric acid and the liquid evaporated until sulphuric acid fumes are evolved. On re-dissolving in water, the iron is precipitated by a slight excess of ammonia, the precipitate being freed from nickel and cobalt by dissolving in sulphuric acid, then re-precipitated and titrated with permanganate, ammonium sulphate being added to the filtrate, from which the nickel and cobalt are deposited by a 0·48 ampère current.

Silver is estimated from the electrolysed copper, or, if in small proportion, from a fresh (10 to 50 grammes) sample, by solution in nitric acid, precipitation as silver chloride, which is purified by re-precipitation, and electrolysed from solution in potassium cyanide.

Lead is determined from a separate sample (10 grammes) dissolved in a large volume of nitric acid, and precipitated as hydrated dioxide of lead (PbO_2) by a 0·3 ampère current, the oxide being de-hydrated by heating to 120° Cent. for half-an-hour.

Sulphur.—From 5 to 20 grammes of the copper are dissolved by nitro-hydrochloric acid and the sulphur determined therein by the usual method.

C. S.

FORMATION OF THE DIAMOND DEPOSITS OF SOUTH AFRICA.

Zur Theorie der Diamantlagerstätten in Südafrika. *By* Dr. Georg Gürich. *Zeitschrift für Praktische Geologie,* 1897, *pages* 145-148.

As is wellknown, the diamond deposits of Kimberley consist of vertical, slightly conical pipes approximately circular in cross section; their walls show vertical striations. They lie in an approximately straight line. The blue ground that fills them consists of a serpentinous cement containing numerous inclusions of the same serpentinous substance, variously coloured, and fragments of numerous minerals and rock-masses. The latter are known as boulders, or when very large, as floating reefs; they consist of fragments of the enclosing rocks of the Karoo formation, mostly of diabase and amygdaloid; there are also fragments of rocks belonging to the deeper-lying Cape formation, and of a cherzolitic rock containing olivine, pyroxene, and other minerals. The most plentiful mineral inclusions are olivine, pyroxene, garnet (pyrope), iron pyrites, and diamond, the latter forming 0·000,002,5 to 0·000,050 per cent. of the whole. All the minerals occur frequently in fragments, except the pyrites, which always form uninjured crystals. The contents of each pipe are split up into a number of vertical columns of somewhat different petrological habitus, separated from each other by thin fissures, filled partly with calcspar and other minerals. The richness of these columns in diamonds is also variable.

The author agrees with Prof. Daubrée's opinion, that the pipes are funnels formed by explosive action, which forced upwards the magma; he suggests that several partial explosions may have united simultaneously to form the grand explosion, and that contraction on cooling produced afterwards the various columns [his explanation is, however, far from intelligible, H. L.]. Basing his opinion on Prof. Moissan's experiments, he holds that the carbon was contained in the basic magma in the form of metallic carbides, and that the carbon separated out from these under great pressure in the form of diamonds.

The occurrence of the vents in a south-south-east and north-north-west line indicates that the first cause of the fission was tectonic, and the deposits were therefore formed during one and the same epoch. The fissure thus formed allowed water to penetrate to the basic magma, and the explosion may have been due to the vapour thus generated, or its violence may have been increased by the gases produced by the action of water upon the metallic carbides.

As regards the age of the deposits, they are naturally more recent than the Kimberley shales, whilst they are parallel to the western edge of the Continent, along which Cretaceous rocks are deposited; hence it may be concluded that the tectonic action to which these north-north-west lines are due was pre-Cretaceous.

H. L.

RECENT EARTHQUAKES IN BOHEMIA.

Einige Bemerkungen zu dem Erdbeben von Graslitz, vom 25 October bis 7 November, 1897. *By* F. E. Suess. *Verhandlungen der k.k. geologischen Reichsanstalt, Vienna,* 1897, *pages* 325-328.

The first feeble shocks took place at Graslitz and Bleistadt in north-western Bohemia, between 2 and 3 a.m. on October 25th, 1897, frequent shocks taking place during the following days, till on October 29th a period of great seismic disturbance set in, violent shocks succeeding each other from 6·24 a.m. on that day until 8·42 a.m. on October 30th. Shocks of diminishing intensity continued

more or less till November 6th, when another period of great disturbance set in, culminating in an extremely violent shock on November 7th, at 5 a.m. After-shocks made themselves felt on various dates up to November 16th.

The area over which the earthquake extended increased in a ratio coincident with the increase in violence of the shocks. It was recorded at localities far into Saxony and Bavaria, as well as in Bohemia, and great stress is laid on the fact, that it was not the first (October 25th) but the second and third series (October 29th and November 7th) of shocks that were the most violent.

In the copper-mines at Schwaderbach, which are worked in very fissile slates, the shocks were very much felt, and several falls of rock took place. The seismic epicentrum lay just between this locality and Graslitz, a fact which helps to account for the especial intensity of the earthquake here.

The author points out that this earthquake, in all probability, belongs to the group of tectonic earth-movements described by Prof. H. Credner in former years as the Erzgebirge-Vogtland group, and the centre of disturbance is gradually shifting along a north-and-south line. L. L. B.

EARTHQUAKE AT AIDIN, ASIA MINOR.

Sulla Velocità di Propagazione del Terremoto d'Aidin (Asia Minor) del 19 *agosto* 1895. *By* G. Agamennone. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1898, *series* 5, *vol. vii., pages* 67-73.

Of this earthquake, the author gave a detailed account in Dr. Gerland's *Beiträge zur Geophysik*, vol. iii., part 3, Leipzig, 1897 ; and the chief object of the present paper is to emphasize the velocity and wide area of propagation of earth-shocks.

The movement was most intense along the valley of the Meander, reaching the degree ix.-x. (of the De Rossi-Forel conventional scale) at the epicentrum, which was a little east of Aidin in lat. N. 37° 51′ and long. E. of Greenwich 27° 55′. The violence of the shock was so great that it was very plainly felt along the western coast of Asia Minor, also 60 miles north and 60 miles south of the epicentrum, and 120 miles east of it. The seismic waves perturbed the micro-seismograph in far-off Padua and the horizontal pendulum in still more remote Strasburg, localities some 1,200 to 1,500 miles away from the epicentrum.

Reducing the time at each locality to a common standard, Constantinople mean time, the author finds that the first shocks travelled to Padua at the rate of 6 miles a second, and to Strasburg at the rate of about 2 miles a second, and the maximum shocks at the respective rates of 2 miles and 1½ miles per second. The great discrepancy between the figures for Padua and Strasburg as regards the first rapid shocks may be in part due to the fact that those which began to disturb the seismograph at the former place were too feeble to disturb visibly the horizontal pendulum at the latter. This instrument, however, began to record the less rapid but more violent shocks, and the commencing shocks of Strasburg were no doubt the same as the maximum shocks of Padua.

The data thus obtained appear to throw doubt on the value of Prof. Cancani's theory of longitudinal and transverse waves, from which hitherto the bases of calculation of the distance of the epicentrum from the point of observation have been derived. The author admits, however, the association with every great earthquake of slow transverse oscillations similar to the great undulations of the ocean, but their velocity has no connexion with that of the longitudinal vibrations postulated by the Cancani theory. L. L. B.

CENTRAL CONDENSATION-PLANT.

Die Central-Kondensation der Zeche Ewald bei Herten. *By* Fr. Koepe. *Glückauf*, 1896, *vol. xxxii., pages* 838-841, *and plate.*

The modern method of applying the condensing principle to colliery-engines consists, not in providing each separate engine with an independent condenser, but in constructing a common condensing-plant into which several engines may exhaust. The plant consists of a surface-condenser, cooled by means of draught induced by a chimney; its object is to condense the exhaust steam by means of mine-waters that are useless for steam-raising purposes, and to return the condensed water to the boiler-feed. The advantages secured are: an economy of coal of 25 to 30 per cent. by the vacuum in the engine; a further economy of about 5 per cent. of coal by the avoidance of incrustations in the boilers; an economy of water of about 424 to 565 cubic feet per hour; economy in boiler-cleaning and boiler-repairs, combined with a higher degree of safety; and economy in the first cost of the boilers.

The plant consists of a condenser, with cooler and chimney, and of pumps. The condenser is formed by a large receiver, from which pass six sets of brass tubes, each pair of which is in communication. A stream of mine-water runs down over the receiver and tubes: the whole plant standing under the chimney so as to be constantly kept cool by the induced air-current. The cooler consists of a series of inclined planes arranged step-wise one below the other, over which the water used to condense the steam has to pass, whereby it is cooled down and can be used over again. The boiler feed-pump is arranged to take the condensed water from the warmest part, whilst the air-pump draws air that has been cooled as much as possible. The circulating-pump is an Encke rotating-pump. The condensed water is filtered to remove any lubricating oil it may contain.

This plant has been in operation since the beginning of June 1896. The vacuum is 85 to 90 per cent., the temperature of the external air being 25° to 30° Cent., that of the air from the air-pump 30° to 32° Cent., and that of the condensed water 48° to 50° Cent. The average coal-consumption in the last four months of working without condensing was 5·26 per cent. of the output, and in the first three months, with the condenser in operation, 4·34 per cent., although only about two-thirds of the engine-power of the colliery are at present connected to the condenser. The saving in coal, realized as above, is calculated at £1,260 per annum, together with a saving in the cost of water, hitherto purchased, of £350, so that the total annual saving amounts to £1,610.

The condensing-plant is constructed to take 22,000 lbs. of steam per hour, but will suffice for 26,500. Its total cost, including pipes and foundations, was £4,000, but against this must be set the saving of at least two boilers, costing £1,250, that would otherwise have been required, so that the first cost will be recouped in about 18 months' working. H. L.

EXPLOSIONS IN AIR-COMPRESSORS.

Explosionen an Luftkompressoren. *By* Ferd. Strnad. *Glückauf*, 1897, *vol. xxxiii., page* 789, *and* 7 *illustrations.*

At the works of Messrs. L. A. Riedingen, Limited, in Augsburg, an experimental air-compressor has been in operation for a good many years; it is a belt-driven compressor, with a cylinder 6·9 inches in diameter, $13\frac{3}{4}$ inches stroke, working at 132 revolutions per minute; the valve-gear consists of a circular (revolving) slide-valve, which serves both cylinder-ends. The valve-chest lies underneath the cylinder, and is connected with it by means of two long, narrow

passages. The cylinder body, the upper part of the long narrow ports, and the upper portion of the valve-chest are externally cooled by means of water, the rest of the valve-chest and the cylinder-ends only by exposure to the atmosphere. Lubrication is effected by means of a lubricator fixed on top of, and in the centre of the compressor; the oil trickling down is distributed by the movement of the piston over the inner surface of the cylinder, and thence passes through the long, narrow ports into the valve-chest.

Various lubricating-oils were tested in this compressor, and especially valvoline oils, which are especially prepared for resisting high temperatures. It was found that with such oil of the highest quality, mixed with a little petroleum, the compressor would continue to work uninterruptedly as long as the gauge-pressure did not exceed 5 atmospheres. When it rose, however, to 7 to 8 atmospheres, it was noticed that in a few days the inspiration of air became gradually less and less, and finally ceased altogether. The valve continued to move regularly, but no air was drawn in.

Upon opening the compressor, it was found that the long narrow passages or ports between the cylinder and the valve were completely filled with the decomposed lubricant, which formed so firmly coherent a mass that it had to be removed by means of a scraper, and in places even by hammer and chisel. When ordinary machine-oil was used, the ports became stopped up in from 5 to 12 days, the length of time affording a very sensitive test for the quality of the oil. This rapid decomposition of the oil cannot be due to high speeds, as the piston speed is only about 295 feet per minute, and similar compressors, but with independent circular valves, one for either cylinder end, have worked quite successfully at 7 to 8 atmospheres. The obvious conclusion is that the fault lies with the long narrow ports. The deposit is caused either by the heat generated in the cylinder during the compression, or else by the oil which can trickle down the sides of the cooled cylinder being decomposed by the heated walls of the ports; possibly both actions occur together. In proportion as the deposit forms and the area of the ports is decreased, the pressures during compression must rise, attended by a simultaneous increase of temperature. Long narrow S-shaped passages, such as are usual in air-compressors, should accordingly be avoided.

It is also advisable that the entrance of the compressed air into the receiver and its exit should not both be at the top of the receiver, but one at the top and the other at the bottom, so that the contents of the receiver may be continually swept out, and no opportunity given for the accumulation of explosive oil-gas.

As the formation of such gas in air-compressors can never be quite avoided, the following precautions should be observed for the sake of preventing explosions:—

1. No pockets should exist in the air-conduit.

2. If it is desired to compress to more than 3 to 4 atmospheres, compound (stage) compressors should be employed.

3. If a single-stage compressor has to be used, it should have short ports and independent valve-motion for each end of the cylinder; in other cases, only so much oil should be introduced into the cylinder as will suffice for its lubrication, the valves being lubricated independently. Of the various types of valve, slide-valves are preferable, because they admit of a much greater speed of revolution.

4. If, for the sake of economy, a single-stage fast-running compressor is employed, it is absolutely necessary to clean it thoroughly and at regular intervals.

5. The surface-cooling of the compressor should be as effective as possible; nothing, however, is gained by cooling the exterior of the valve-chest unless the valve-faces themselves can be cooled. H. L.

EXPLOSION OF AN AIR-COMPRESSOR AT DORTMUND (WESTPHALIA).

Explosion eines Luft-kompressors auf der Zeche Kaiserstuhl I bei Dortmund. Anon. *Glückauf*, 1897, *vol. xxxiii., pages* 503-506, *and plan.*

An explosion took place on April 30th, 1896, in the air-compressing plant at the Kaiserstuhl I pit of the Westphalia colliery at Dortmund, which was attended with serious consequences. The air-compressor was contained in a massive two-storied building; the receiver was situated close to it, and it was surrounded by the other buildings that formed the surface-plant of the colliery. The compressor was on the Burkhardt and Weiss system, with twin slide-valves, with cylinders 23·6 inches in diameter and 31·5 inches stroke. It was cooled externally by water circulating round both the body and ends of the cylinders; the valve-chests were not cooled. The steam-cylinders were 26·4 inches in diameter, the steam-pressure was 6 atmospheres at the boilers, and the mean working speed was 32 revolutions per minute. The compressed air was conducted by cast-iron pipes, 9·5 inches in diameter and 0·75 inch thick, to the wrought-iron receiver, 7 feet 2 inches in diameter and some 33 feet in length; the latter was provided with two safety-valves, set to blow off at $4\frac{3}{4}$ atmospheres. There was no valve between the compressor and the reservoir.

The air taken into the compressor was freed from dust by filtration through cotton-wool; the valves and air-cylinders were lubricated with an oil bought under the name of *valvoline*, and said to possess a high igniting-point. The valves were lubricated automatically.

The explosion took place about 6·30 a.m., accompanied by a most violent detonation; dense fumes rose from the building, the roof of which had been blown off, whilst all inflammable materials inside it were set on fire. Much damage was done to the building, though the compressor-cylinders suffered but little; but the valve-chests, 1·2 inches in thickness, were blown off. The interior of the cylinders, the valves, and the remains of the valve-chest were covered with a black greasy coating, which was solid in places and showed signs of incipient coking. A sootlike and more or less firm crust was also found lining the air-pipes.

The air-receiver had completely disappeared, its site being covered with a heap of bricks, tiles, and rubbish; it had been completely blown to pieces, one fragment over 1 cwt. in weight being found a mile away, whilst the largest piece, weighing 76 cwts., was thrown clear over a building 100 feet in height.

The origin of the explosion is indicated by the fact that a sootlike body was found coating parts of the interior of the machine, and this could only be produced by the lubricating oil employed. The temperature of the valve-chest must have been sufficiently high to decompose this oil, generating gases which, mixed with compressed air at a high pressure, formed a most violent explosive mixture.

As the cause of the explosion had to be sought in the lubricating oil employed, it was considered advisable to have the latter tested at the Berlin Royal Chemico-Technical Institute. The report stated that the valvoline oil submitted must be designated a good lubricant; its density was 0·89 at 15° Cent.; it was free from animal and vegetable oils, and consisted of hydrocarbons that had taken up but little oxygen. The flashing-point in the open crucible was 291° Cent., its boiling point 375° Cent. These figures indicate that care had been used in its manufacture. When such oils are dropped into red hot retorts they are decomposed, gaseous products and a coke-like residue being formed; in this way 20 grammes of the lubricating oil can convert 1 cubic metre of air into an explosive mixture. There are no lubricating oils that are incapable of being decomposed by heat with the formation of combustible gases.

The considerable quantity of residue found in the valve-chest shows that, in spite of the high character of the oil, considerable quantities of it had been decomposed. The prime cause of the accident must therefore be ascribed to the defective cooling of the valve-chests.

Several explosions of similar nature, but of very trifling character, have occurred in the Dortmund mining district. Although an explosion of so serious a character as the one here described is quite exceptional, and must be ascribed to the accidental coincidence of a number of contributing circumstances, it nevertheless demonstrates that in compressers fitted with slide-valves the greatest attention must be bestowed on the quality of the lubricant, upon the most efficient system possible of cooling the valves, and upon keeping them clean and free from oil-residues and particles of coal-dust. H. L.

EXPLOSION OF FIRE-DAMP IN THE ROCK-SALT MINES AT AKNA-SZLATINA, HUNGARY.

Eine Grubengasexplosion im Steinsalzwerke zu Akna-Szlatina in Ungarn. *By* L. Litschauer. *Glückauf*, 1896, *vol. xxxii.*, *pages* 935-936.

At Akna-Szlatina, a deposit of rock-salt 2,200 metres (7,218 feet) in length, 1,700 metres (5,577 feet) in width, and of still unknown depth, has been worked from a very remote period. The mine is greatly troubled with water, which makes its way in, under considerable pressure, from subterranean reservoirs. An attempt had been made to tap these by means of levels, one of which had for some time past penetrated into the zone of solution by this water. The cavities thus formed were filled, to a depth of 6 to 8 inches, by a layer of bituminous mud. As fans were kept continuously at work, no one suspected that this would prove a source of danger, so that naked lights were everywhere used. On August 28th, 1896, however, an explosion took place in this part of the mine, by which two miners were hurt severely and one slightly, followed a couple of hours later by a second explosion that killed two miners, who were examining, by means of naked lights, the workings where the first explosion had taken place. It is supposed that gas was forced into the mine by the sudden collapse of cavities, dissolved out as before mentioned.

H. L.

EXPLOSION IN THE RESCHITZA PITS ON DECEMBER 18th, 1896.

Die Grubenkatastrophe in Reschitza am 18 Dezember, 1896. *By* Robert Lamprecht. *Glückauf*, 1897, *vol. xxxiii.*, *pages* 21-24.

The Reschitza collieries are situated about 2 miles south of Reschitza in Southern Hungary. The coal occurs in basins of crystalline schists, in which the Lias formation has been deposited, and which are greatly faulted, disturbed, and folded. There are two workable coal-seams intercalated between sandstones; their thickness varies from 1·5 to 3 metres (5 to 10 feet), and they are separated by a distance of 40 metres (131 feet). The general strike is east to west, and the dip 30 to 70 degrees south. There are two main shafts, the Szecsen 460 metres (1,510 feet) deep, and the Almasy 390 metres (1,280 feet) deep, situated 700 metres (2,300 feet) to the west of the former. A day-drift 2,250 metres (7,382 feet) long, fitted with an electric railway, is used to run the coal out. There are six working-levels below the day-drift in the Szecsen shaft and five in the Almasy shaft. The latter is ventilated by a Pelzer fan, 2·5 metres (8 feet) in diameter. The Szecsen shaft acts

as an intake, a Guibal fan of 9 metres (29 feet 6 inches) in diameter, and 2 metres (6 feet 6 inches) wide being erected close to the mouth of the day-drift, and connected with it by means of a fan-drift. The air is brought through the levels running parallel to the strike, and returns by a return-air drift, driven 6 metres (20 feet) higher up. The mine is so gassy that stentings have to be driven to connect the two drifts about every 10 metres (33 feet). The pillars are worked by overhand stoping.

The explosion occurred at 6·30 p.m. on December 18th, 1896, when there were 128 men in the pit in the back-shift. A huge column of flame shot out from the downcast shaft, set the timbering of the shaft and the wooden poppet-heads on fire, destroyed the doors, windows, and roof of the engine-house, and killed two men who were at the pit-head. Out of all the men in the shaft only 34 were saved.

The explosion is supposed to have originated at the westerly face of the main north level of the Szecsen pit in the top seam, which had been driven for a length of 90 metres (295 feet) from the crosscut to the shaft, which was itself 420 metres (1,377 feet) in length. At this spot, the coal was very hard. The air in the face had been tested by a deputy before the accident by means of a Wolf benzine safety-lamp and 1½ per cent. of gas had been found ; the place was nearly free from dust. In the afternoon, the firemen had fired two dynamite shots electrically in this place. The water-gauge up to the time of the explosion was pretty steady at 5·5 millimetres (2·16 inches), but it dropped on an average twice in the hour down to 20 millimetres (0·79 inches), this fall being due to the opening of the doors in the day-drift for the passage of the sets of tubs. At the time of the explosion, the water-gauge rose to 90 millimetres (3·5 inches) owing to the effect of the blazing shaft, the direction of the ventilation being thereby reversed.

There seems little doubt that the explosion was caused by a safety-lamp, which may either have been damaged, or forced open, or may, on its relighting by the existing percussion-ignition, which works upwards inside the lamp, have forced the burning gases out of the lamp.

H. L.

BRUNNER COLLIERY EXPLOSION, NEW ZEALAND.

(1) *Report of Royal Commission appointed to inquire into the Brunner Coal-mine Disaster on March 26th*, 1896.

The coal-face where the explosion occurred is 4,584 feet distant from the adit entrance. The main drive rises for a distance of 1,914 feet from the coal-face, the remaining 2,670 feet to the adit being driven on the level. The area of the mine is about 200 acres, the thickness of the coal-seam varying from 7 to 10 feet. The coal is highly bituminous, yielding from 12,000 to 15,000 cubic feet of gas per ton. Fire-damp had occasionally been met with, but no serious accident had ever occurred. The texture of the coal is compact in the solid, but somewhat tender and friable when mined ; it is moderately moist, and does not readily form a heavy deposit of light dust. All the witnesses agreed that the mine could not be considered as fiery, and could not be classed as dry and dusty. The ventilation is effected by a Schiele fan producing from 16,000 to 18,000 cubic feet of air per minute The coal is worked on the board-and-pillar system.

The explosion occurred about 9·25 a.m. on March 26th, 1896, killing all workmen in the mine, numbering 65 persons.

The mine was worked by open lights, except on a few occasions, when safety-lamps were ordered to be used in certain parts. At the time of the accident open lights were used throughout the mine, with three exceptions, where Marsaut lamps were employed. The explosive used was blasting-powder. The explosion was caused by a blown-out powder-shot, fired by a person unknown, contrary to the rules of the mine. The flame ignited the fire-damp evolved from the surrounding coal, which in turn ignited the coal-dust raised by the concussion of the shot. It was assumed that the explosion was locally intensified by small quantities of fire-damp. There was no direct evidence that the explosion was commenced by the ignition of an accumulation of fire-damp.

There was no evidence of working-tools being found at the place, and as there was no holing or undercutting it was assumed that an old shot-hole, drilled some ten months previously, had been used. An estimate of the coked coal-dust in the mine resulting from the explosion showed that 12,000 to 15,000 cubic feet of gas had been liberated.

Three days were occupied before the rescuing party were able to reach the workings, owing in a great measure to the presence of carbon monoxide gas or white-damp.

Owing to the soft nature of the floor and the hard nature of the roof, brick-stoppings could not be built, and the method adopted was "crib-logging," consisting of two walls of heavy timber, the intervening space being filled with stones and dirt. This method was considered very satisfactory.

The following suggestions are made for the better working of coal-mines:—No inspector of mines should be appointed who has not qualified by examination and practice as a colliery manager; every inspector should have a safety-lamp capable of testing $\frac{1}{2}$ per cent. of gas; an inspector, after visiting a mine, should place a copy of his report on the pit-heap. Underviewers, deputies, or foremen should be required to pass an examination before the inspector of mines, and, if qualified, receive a certificate. A. C. K.

(2) *On the Brunner Mine Disaster.* *By* Sir James Hector. *Transactions and Proceedings of the New Zealand Institute*, 1896, *vol. xxix., page* 602.

The writer states, as evidence of the terrific effects of the explosion, that the smoke came to the outlet against the draught to the workings; that the coal was charred over a very large area to a depth of 4 inches; and that the body of one man was driven up an incline of 300 feet and smashed against the wall of coal. At the top of the incline (at the motor-house), a man was smashed to pulp and a boy stripped of every particle of his clothing without being burned in the slightest degree. The explosion was, it was conclusively proved, not of fire-damp, but an imperfect explosion of coal-gas, leaving white-damp—the most deadly of all damps, $\frac{1}{2}$ per cent. of which would be fatal if continuously breathed.

The explosion may have been caused by a miner putting in a large charge of blasting-powder in an imperfect manner, so that instead of breaking down the coal it blew out like a cannon-shot and so caused the explosion.

The evidence at the inquest showed that this noxious gas arose from imperfect combustion, and was carbon monoxide, or white-damp, and that the foolish conduct of the person who fired the shot had been the cause of the disaster. The author mentions that a flameless explosive was used at the Kaitangata mine, and it had proved most successful. M. W. B.

THE COAL-DUST QUESTION.

(1.) *Procédés employés pour combattre les Poussières dans les Mines de Houille.* ANON. *L'Industrie*, 1897, *page* 165.

All the methods employed for counteracting the effect of dust (besides its removal) have the object of rendering it damp, and may be classed under five categories, accordingly as they depend on the use of sea-salt or other hygroscopical substances, steam, damped surfaces, water-carts, or water-pipes laid throughout the workings. A saline solution may be efficaceous, if the results of experience in towns near the sea be considered applicable to mines.

It is acknowledged that damped surfaces produce a good effect by moistening the air-current, which thus has less tendency to dry the dust, while in some cases they may assist the ventilation. The advisability of damping at intervals portions of the workings is recognized; and in the Saar district the regulations require that a length of 164 feet (50 metres) of workings between two districts shall be rendered moist. If the downcast shaft be damp, the entering air will be saturated with water while the ventilation will be assisted. At the Planitz mine, in Saxony, the air-current passes across a wooden paddle-wheel partly dipping into water,

Most of the methods adopted, or at any rate known, in Great Britain are described, and dismissed with the observation that they all have their advantages, but that no one of them appears susceptible of general application, while an excellent precaution consists in watering the bodies of the tubs before they leave the working-places.

At the Hibernia colliery, near Gelsenkirchen, Westphalia, a method of watering the coal-dust has been adopted, which the Mine Administration has lately made obligatory in all the seams of this colliery. The water required is stored in a lodge of 19,494 cubic feet (552 cubic metres) capacity, formed by an old cross-cut, arriving clarified by passing through a filter-bed 6 feet 6 inches (2 metres) thick, and is distributed in the workings by a system of pipes 150,333 feet (45,820 metres) long and of three different diameters, the smallest being 1 inch (26 millimetres) in diameter. The pipes are of galvanized wrought-iron in $16\frac{1}{2}$ feet (5 metres) lengths, with flanges for connexion. Every 164 feet (50 metres), and also at the end of each branch, there is a stand-pipe with cock and screw-union, their total number being 1,016. The sprinkling is effected with hose-pipes screwed on to the stand-pipes and terminating in nozzles of $\frac{1}{8}$ inch (3 millimetres) diameter, partly by the miners and partly by 13 men specially appointed for the purpose. The cost of laying, extending, maintaining and working the system from July 1st, 1890, to June 1st, 1895, amounted for materials to £4,816 (96,319 marks), and for wages to £4,124 (82,480 marks), forming a total of £8,940 (nearly 178,800 marks); and the cost for materials and wages during 1894 amounted to £2,577 (51,550 marks). J. W. P.

(2) *La Question des Poussières de Charbon. By* ARMAND HALLEUX. *Bulletin de l'Association des Ingénieurs de Liége*, 1896, *vol. xx., page* 12.

Inasmuch as it is an acknowledged fact that an atmosphere, free from fire-damp, but charged with fine coal-dust, is explosive, there is every reason to search for and study the physical and chemical factors which intervene in rendering coal-dust more or less dangerous. The physical characteristics, however—tenuity and porosity—are of slight importance compared with the chemical characteristics, a study of which latter includes examination into the nature and quantity of the gases that coal-dust may contain in the occluded state.

After having pointed out the relation which exists between the occlusion of gases and the origin of coal, the author describes the methods of investigation and results obtained in Germany by Prof. von Meyer, and also in Britain, where the combustible gas was found to consist, not only of fire-damp, but also of other and denser hydrocarbon gases. It is precisely, he remarks, on the larger or smaller quantity of these dense hydrocarbon gases that depends the degree of inflammability possessed by the coal-dust; and it is these occluded gases which, set free by a raising of the temperature, caused by a mine-shot for instance, combine with the oxygen of the air. A noteworthy circumstance is that their ignition-point is lower than that of fire-damp, and also that for bringing about an explosion they require a far larger volume of oxygen than does fire-damp.

This question is of the highest importance in countries like Belgium, where the coal-deposits are worked at a constantly increasing depth; and its study is the more easy, as all that is required is to apply established principles. J. W. P.

METHODS USED FOR DIMINISHING THE DANGER OF COAL-DUST IN THE GOVERNMENTAL COAL-MINES OF THE SAAR DISTRICT.

Die zur Bekämpfung des gefährlichen Kohlenstaubs auf den staatlichen Steinkohlengruben im Saarrevier getroffenen Einrichtungen, ihre Bewährung und ihre Kosten. By Berginspektor Zorner. *Glückauf*, 1895, *vol. xxxi., pages* 1207-1208.

The following are the chief methods of moistening coal-dust, used in this district:—

(1) The system of preventing dust before its formation, known as the Meissner system. This consists in drilling 1 to 3 holes, about 3 feet deep in the face, in the night-shift, plugging these holes, and forcing in water, which can then penetrate all portions of the solid coal. Generally, 8 hours suffice to soak the coal, so far that no dust is made during the process of getting the coal. The method is best suited for tender open coals, and is not suitable for hard coals, much fissured or jointed, or where either roof or floor are soft, and liable to swell.

(2) The dust may be damped down either continuously by spraying, or intermittently by water with hose, with or without a jet. The former method is more suitable for the travelling-roads where the air-current has considerable velocity, the latter for working-faces, though removable hoses that can be attached to hydrants, some 100 or 150 feet apart, are also used in the roadways. The former method consumes much water, but costs little for labour; whilst with the latter the opposite conditions prevail.

Instead of these methods, watering-carts, watering-pots, fire-engines, or force-pumps, may be used in particular cases.

(3) Wet zones, on wetted sections of the roads, should be maintained, so as to localize explosions as much as possible. Such sections should be 200 to 300 feet long, both in the main ways and in the return air-ways, so as to divide the various portions of a mine.

Cost of Plant.—The first cost of a system of pipes 39,400 feet (12,000 metres) long, at the Camphausen mine, was £1,500 in 1888, and has now risen to £8,200, with an extension of 19 miles (31 kilometres). The costs at the Maybach mine were similar,* and it may fairly be calculated that such an installation in a normal mine of area 1,400 metres (4,500 feet) by 1,000 metres (3,300), and working three seams, including connexions, taps, etc., would cost £2,500 to £3,000. The working costs have been reckoned at 2d. to 7d. per ton approximately. H. L.

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* *Trans. Fed. Inst.*, vol. ix., page 90.

ELECTROLYTIC GAS AS AN EXPLOSIVE.

Ueber Versuche mit Knallgaspatronen. By Bergassessor Heise. *Glückauf*, 1897, *vol. xxxiii., page* 869.

Dr. Wilhelm Ochse has patented a method of employing electrolytic gas, produced by the electrolysis of water, as a blasting agent. He uses small steel cylindrical shells 180 millimetres (7 inches) in length, 30 millimetres (1·2 inches) in diameter, and 2·5 millimetres (0·1 inch) in thickness; their volume amounts to 80 cubic centimetres (4·9 cubic inches), and they are calculated to withstand a pressure of 1,200 atmospheres. The cylinder is filled with 22.5 grammes (350 grains) of distilled water to which 2·5 grammes (38·5 grains) of chemically pure soda are added, so as to improve the electrical conductivity of the water. An iron plug is screwed in, through which pass two iron pins insulated by means of vulcanite. After the cylinder has thus been thoroughly closed, an electric current of 8 to 10 volts tension and 0·85 to 1·0 ampère strength is passed through the iron electrodes. According to the inventor, the evolution of oxygen and hydrogen depends only on the strength of the current, and is not affected by the pressure in the receiver. The water is slowly decomposed, the steel shell becoming slightly warm, owing to the compression of the gas. At the end of 40 hours, 20 grammes (308 grains) of water had been decomposed, the pressure inside the shell being equal to 450 atmospheres. In that condition, the shell was ready for use in the ordinary way like an ordinary cartridge of any explosive.

In sloping shot-holes, the shells must always be so charged that the stoppered end shall be uppermost. The shot is fired by sending a spark between the electrodes from a Nobel or Bornhardt electrical machine. If several shells are to be used in one shot-hole they must be connected in series and included in the current, because the explosion of a shell would not otherwise determine that of others in contact with it. The experiments tried with this method of shot-firing in stone indicated that the explosive force of a shell was about equal to that of 150 grammes (5 ounces) of any of the ordinary ammonium-nitrate explosives.

The inventor hoped that the extreme rapidity of the explosion of electrolytic gas would cause the extinction of all flame before the steel shell had time to burst, and that his method could therefore be used safely in gassy and dusty mines. Experiments, however, proved that this hope was ill-founded, and that these shells will fire explosive mixtures; the inventor had, therefore, not taken any steps towards the introduction of this new method of blasting. It is also doubtful whether it is adapted for practical working. H. L.

OCCURRENCE OF FIRE-DAMP WHILE SINKING IN THE RUHR COAL-FIELD, GERMANY.

Auftreten von Schlagwettern beim Abteufen des Schachtes Schürenberg des Steinkohlenbergwerks Ewald bei Herten. By Bergreferendar von Velsen. *Glückauf*, 1896, *vol. xxxii., pages* 893-896.

Whereas, in the Ruhr coal-field, water has hitherto been regarded as the only difficulty of any consequence to be contended with in sinking shafts, another—that from fire-damp—showed itself while the Schürenberg shaft, 13 feet 3 inches (4·05 metres) in diameter, of the Ewald colliery was being put down. At the depth of 886 feet (270 metres) the marl was found to be much fissured; and, as it was feared that the clefts might reach down to the Coal-measures (the speedy occurrence of which was expected) and give out fire-damp, orders were given to try

for gas with the safety-lamp after every shot was fired and before each change of shift. This fear proved well founded, because on May 18th, 1896, fire-damp issued from a cleft in such quantities that it became necessary to interrupt the work.

When a depth of 98 feet (30 metres) had been reached, in order to provide the men at the bottom of the shaft with fresh air, an air-pipe 13 inches (34 centimetres) in diameter was put in and connected with a chimney on the surface, and lengthened as the work proceeded. When the fire-damp showed itself, a second air-pipe, 16 inches (40 centimetres) in diameter, was added, and connected with a Capell exhausting-fan 30 inches (75 centimetres) in diameter, which kept the bottom of the shaft so far free from gas that the work could be continued with special precautions—safety-lamps only being used, the dynamite-cartridges being fired by electricity, and the shots being tamped with water—while, after the holes were charged, the whole shaft-bottom was covered with water before firing. At the depth of 961 feet (293 metres) a crib was put in for the masonry-walling, which, on being carried up, closed the gas-yielding cleft. To prevent an accumulation of fire-damp behind the walling, a gas-pipe was built in; but the rocks again showed such large clefts, yielding fire-damp, that the sinking could proceed but slowly.

At the depth of 1,030 feet (314 metres), water under great pressure burst through two boreholes into the shaft, the flow ceasing after ½ hour; but the water was followed by fire-damp in such quantities, and under so great a pressure, that in an instant the whole shaft-bottom was filled with gas, so that the sinkers had to make their way up in the dark. In three hours the fire-damp stood 230 feet (70 metres) high in the shaft.

The above-named air-pipe was then replaced by two others, 16 inches and 20 inches (40 and 50 centimetres) in diameter, each connected with an exhausting-fan, which again freed the shaft-bottom from gas. As, however, fire-damp still showed itself in large quantities, portable incandescent electric lamps were used for lighting.

Further sinking of the shaft laid open a rather wide fissure, which gave out fire-damp; and, when the gas disengagement ceased, the remarkable circumstance occurred that the fissure sucked in water to such an extent that, in a week's time, the shaft-bottom became completely dry. On July 22nd, 1896, at a depth of 1,074 feet (327·4 metres), the Coal-measures were reached, containing the first seam of gas-coal, 9 inches (22 centimetres) thick, dipping 10 degrees; and from the fissured sandstone fire-damp issued with considerable force, accompanied by so loud a noise that not a word could be heard at the bottom of the shaft.

Six shots were to be fired the same evening; but only three could be charged, as the cartridges were blown out of the holes by the gas. The men were obliged to leave the shaft, because the gas increased so much that, about 10 p.m., it rose in the shaft to a height of 558 feet (170 metres); and although three fans were run at full speed, together exhausting 8,413 cubic feet (238·23 cubic metres) per minute, it was only possible to reduce the gas to a height of 105 feet (32 metres) above the pit-bottom. The two fans, which drew from the smaller air-pipes only, exhausted 4,088 cubic feet (115·77 cubic metres); while the other, drawing from the larger air-pipe, exhausted 4,335 cubic feet (122·75 cubic metres), or more than the other two fans together, the fans being of nearly equal power; and this circumstance shows what influence a reduction of the sectional area exerts on a fan's duty.

As it was found impossible to keep the shaft clear of gas by these small fans, a Winter ventilator, 9 feet 10 inches (3 metres) in diameter, guaranteed to exhaust 63,570 cubic feet (1,800 cubic metres) per minute, was erected, and put into communication with an air-tight box, 18 square feet (1·7 square metres) in sectional

area, led up to the surface. In two hours, it completely cleared the shaft of the gas, which had risen to the surface, so that sinking could proceed; and at the depth of 1,083 feet (330 metres) the fissure was closed by masonry, gas pipes being, at a further depth of 65 feet (20 metres), built behind the shaft-walling, and connected with the air-box. As considerable quantities of gas continued to issue from these pipes, they were united into one, led up to the surface; and the gas (containing 70 per cent. of fire-damp, with $1\frac{1}{2}$ per cent. of carbon dioxide, the remainder being atmospheric air), was utilized for firing the steam-boilers. J. W. P.

OCCURRENCE OF INFLAMMABLE GAS IN ORE-MINES.

Förekomst af brännbar Gas i Malmgrufvor. *By* G. Nordenström. *Geologiska Föreningens i Stockholm Förhandlingar*, 1896, *vol. xviii., page* 637.

A bore-hole was being bored by means of a diamond boring machine in one of the drifts of the Vieille Montagne Company's zinc-mines at Åmmeberg, when after boring 125 feet (38 metres) into granulite between two deposits of zinc blende, inflammable gas and water were given off in great quantity. The gas had the following composition:—

Light carburetted hydrogen, CH_4	51·0
Heavy ,, ,, C_2H_4	0·5
Carbon dioxide, CO_2	1·5
,, monoxide, CO	1·2
Hydrogen, H	1·0
Nitrogen, N	44·8

Under somewhat similar conditions, gas has been given off since 1893 from a bore-hole passing through alternate beds of hälleflinta and limestone in the Dannemora iron-ore mines. The bore-hole was plugged, but on withdrawing the plug water and inflammable gas escaped; the latter had this composition:—

Light carburetted hydrogen, CH_4	33·6
Nitrogen, N	66·4
	100·0

H. L.

VARIATIONS IN THE ISSUE OF FIRE-DAMP.

Du Grisou: ses Lois de périodicité. *By* A. Doneux. *Cosmos*, 1895, *vol. xxxi., pages* 500 *and* 528; *vol. xxxii., pages* 467 *and* 501; *and* 1896, *vol. xxxiii., pages* 273 *and* 308.

The author, whose attention has long been concentrated on the periodicity of seismic disturbances, having been struck with the frequent occurrence of mining catastrophes traceable to no definitely ostensible cause—such as, for example, the explosion at Anderlues colliery on March 11th, 1892—was led to examine the question more minutely, with the result that he believes that by the application of Prof. Brück's ideas, a connexion may be traced between the issue of fire-damp and the laws of volcanic action.

From statistics of the mine explosions in Belgium between the years 1851 and 1879 arranged in Table I., it appears that, generally speaking, explosions occur most frequently at the end days of the magnetic week and at the period of the monthly change, for about three-fifths of the year, the remaining two-fifths not exhibiting this peculiarity, on account of other disturbing influences.

TABLE I.—FIRE-DAMP EXPLOSIONS (EX.), WITH KILLED (K.) AND INJURED (I.) IN BELGIUM FROM 1851 TO 1879, ARRANGED ACCORDING TO THE DAYS OF THE MAGNETIC WEEK.

Week.	Days of the Weekly Fluctuation.																							
	1.			2.			3.			4.			5.			6.			7.		
	Ex.	K.	I.	Ex.	K.	I.	Ex.	K.	I.	Ex.	K.	I.	Ex.	K.	I.	Ex.	K.	I.	Ex.	K.	I.
December 27 to January 2 ..	1	0	6	1	5	2		—			—			—		1	2	7		—	
January 3-9	1	57	3	2	12	7	2	1	2		—		1	0	3		—			—	
,, 10-16		—		1	7	18	1	13	17		—			—			—		1	4	1
,, 17-23	1	8	18		—			—		1	0	1		—		3	27	7	2	0	1
,, 24-30		—		1	0	4		—			—			—			—			—	
January 31 to February 6 ..	1	8	5	2	1	9		—			—		1	1	0		—		2	8	4
February 7-13 .. .. P	1	1	4		—		2	1	8	1	2	2		—			—			—	
,, 14-20..	1	0	3	1	0	2	2	2	6		—			—			—			—	
,, 21-27 .. .. P	1	0	1		—			—			—		3	5	4		—			—	
,, 28 to March 6 ..	2	27	11	3	9	8	3	1	8	2	5	14		—			—		2	66	6
March 7-13	2	1	1		—			—		1	1	2		—			—			—	
,, 14-20	1	0	3	1	2	5		—			—		1	0	4		—			—	
,, 21-27 .. .. P		—		1	5	16	1	2	3		—		1	3	0		—			—	
,, 28 to April 3	1	0	1	3	0	4	1	0	3	1	0	2		—		1	16	10		—	
April 4-10 .. .. P		—			—			—		1	1	0	1	0	3	1	1	2	1	6	0
,, 11-17	1	0	4	2	1	7	1	1	0		—		2	4	4		—		2	124	11
,, 18-24		—		1	1	1		—			—		2	2	2		—		1	0	6
,, 25 to May 1 .. P		—			—			—			—			—			—			—	
May 2-8		—			—		1	0	2		—			—		1	0	1		—	
,, 9-15	1	0	2		—			—			—			—			—		2	2	5
,, 16-22		—		1	1	6		—			—			—			—			—	
,, 23-29 .. .. P		—			—		1	2	0	1	2	0		—		2	11	0	1	1	0
,, 30 to June 5 .. P		—			—			—			—		1	1	4	1	2	1		—	
June 6-12		—		2	4	2	1	0	2		—		1	4	28		—			—	
,, 13-19		—			—			—			—			—		1	1	5	1	0	3
,, 20-26 .. .. P		—			—			—		2	2	4		—			—			—	
,, 27 to July 3 .. P		—		1	0	2		—			—			—		2	11	4		—	
July 4-10	1	1	0		—			—		1	13	4		—			—		3	4	3
,, 11-17 .. .. P		—			—			—			—		1	0	4		—			—	
,, 18 24 .. .. P		—			—			—		2	0	6	1	1	2		—			—	
,, 25-31		—		1	5	4	3	7	6		—		1	9	6		—		2	27	2
August 1 7		—		1	0	3		—			—			—			—		1	55	0
,, 8-14	4	1	7		—			—			—			—		1	1	0		—	
,, 15-21		—			—		1	0	2		—			—			—		1	1	0
,, 22-28	3	2	12	1	0	3		—		1	7	0		—			—			—	
,, 29 to September 4 P	1	1	1	1	20	9		—			—		2	9	9	1	3	0		—	
September 5-11		—			—			—			—			—			—			—	
,, 12-18 .. P	1	0	3		—			—		2	0	9	1	4	4		—		1	0	2
,, 19-25 .. P		—		2	2	0	1	9	4	1	2	1		—		1	1	1		—	
,, 27 to October 3..	2	37	11	3	2	8		—			—			—		2	1	1		-	
October 4-10	1	3	13	1	0	11	1	1	0	1	0	1	1	0	11		—		1	4	0
,, 11-17		—			—			—			—			—			—		1	7	9
,, 18-24	2	2	0	2	2	7		—		1	1	1		—		1	34	3		—	
,, 25-31 .. .. P	1	7	0		—			—		1	2	5	1	2	0	2	3	4		—	
November 1-7		—			—			—			—			—			—			—	
,, 8-14 .. .. P		—		1	1	1	2	65	5		—		1	0	0	1	2	0		—	
,, 15-21 .. .. P	1	0	1		—			—		1	1	0	1	0	7		—			—	
,, 22-28				1	7	7		—			—			—			—		1	0	2
,, 29 to December 5				1	0	9		—			—		1	0	0		—			—	
December 6-12		—			—		1	1	1	1	0	6	1	0	2		—			—	
,, 13-19		—			—			—		1	112	10		—		1	2	3	2	14	5
,, 20-26		—			—			—			—			—			—		3	3	6

P indicates disturbing influences

If the figures given in the above-named statistics be grouped, the results shown in Table II. are obtained.

TABLE II.—EXPLOSIONS IN BELGIUM.

Days of the Magnetic Week.	1.	2.	3.	4.	5.	6.	7.
Number of explosions ...	*32*	*38*	25	23	26	23	*31*
Victims—Killed ...	*156*	87	106	151	45	118	*326*
,, Injured ...	*110*	*155*	69	68	97	49	66
,, Totals...	*266*	*242*	175	219	142	167	*392*
The averages per accident being—Killed ...	*4·8*	2·3	4·2	*6·5*	1·7	5·1	*10·5*
,, Injured ..	*3·4*	*4·1*	2·7	2·9	3·7	2·1	2·1
,, Totals	8·3	6·3	7·0	9·5	5·4	7·2	*12·6*

The effect of the monthly change on the escape of fire-damp is shown in Table III., wherein are detailed the number of explosions occurring on the day of this change and the seven days preceding and succeeding the same.

TABLE III.—EFFECT OF THE MONTHLY CHANGE ON FIRE-DAMP EXPLOSIONS IN BELGIUM FROM 1851 TO 1879.

First Day of the Monthly Change.	Number of Explosions in Belgium, 1851-1879.													
January 22	—	1	1	—	—	1	—	3	2	—	1	—	—	—	—
February 24	—	—	—	—	1	—	—	—	3	—	—	2	3	3	2
March 21 ...	1	1	—	—	1	—	—	—	1	1	—	1	—	—	1
April 16 ...	1	1	1	2	1	—	2	—	2	—	1	—	—	2	—
May 28 ...	—	—	—	—	1	1	—	2	1	—	—	—	—	1	1
June 21 ...	—	—	—	—	1	1	—	—	—	2	—	—	—	—	1
July 22 ...	1	—	—	—	—	—	2	1	—	—	—	—	1	3	1
August 8 ...	—	1	—	—	—	—	1	4	—	—	—	—	1	—	—
September23	1	—	1	—	2	1	1	—	1	—	2	3	—	—	—
October 10	—	1	1	1	1	1	—	1	—	—	—	—	—	—	1
November 9	—	—	—	—	—	—	—	1	2	—	1	1	—	1	—
December 16	1	1	—	—	—	—	—	1	—	1	2	2	—	—	—
Totals ...	5	6	4	3	8	5	6	13	12	4	7	9	5	10	7

First Day of the Monthly Change.	Number Killed.													
January 22	—	4	8	—	—	—	—	27	—	—	—	—	—	—	—
February 24	—	—	—	—	—	—	—	—	5	—	—	27	9	1	5
March 21 ...	—	2	—	—	—	—	—	—	5	2	—	3	—	—	—
April 16 ...	1	6	—	1	1	—	4	—	124	—	1	—	—	2	—
May 28 ...	—	—	—	—	2	2	—	11	1	—	—	—	—	1	2
June 21 ...	—	—	—	—	1	—	—	—	—	—	2	—	—	—	—
July 22 ...	—	—	—	—	—	—	—	1	—	—	—	5	7	—	9
August 8 ...	—	—	—	—	—	—	55	1	—	—	—	—	1	—	—
September23	4	—	—	—	2	9	2	—	1	—	37	2	—	—	—
October 10	—	3	—	1	—	—	—	4	—	—	—	—	—	—	7
November 9	—	—	—	—	—	—	—	1	65	—	—	2	—	—	—
December 16	—	—	—	—	—	—	—	112	—	2	14	—	—	—	—
Totals ...	5	15	8	2	6	11	61	157	201	4	54	39	17	4	23

The total number of explosions detailed in Table III. is 104, and if the individual totals be compared with the average of the 198 accidents recorded for the whole period under review, viz., 6·5, the two central days stand out prominently. Similar results are obtained from the statistics for France between 1814 and 1883. The number of killed recorded in Table III. (607), emphasizes the influence of the monthly change on the intensity of explosions, the average of the 3 central days being $139\frac{2}{3}$, whereas the average of the grand total only amounted to 32·52.

The annual change shown in Table IV. is somewhat similar in its effects, but in this case they are modified by the influence of the monthly changes.

Comparative indications are also given of the intensity of the explosions as manifested by the proportion of killed to wounded, the former being greatest on the day preceding the weekly fluctuation, and a reversal of the position occurring on the day following. In the case of the annual change, the killed predominate on the day succeeding the change, and the wounded on the next day.

TABLE IV.—INFLUENCE OF THE ANNUAL CHANGE ON THE FORCE OF FIRE-DAMP EXPLOSIONS IN BELGIUM FROM 1851 TO 1879.

First Day of Annual Change.	Number of Killed.														
January 1 ...	—	3	—	5	—	—	—	2	—	—	—	—	—	—	—
February 7	8	1	—	—	1	—	8	1	—	1	2	—	—	—	—
,, 20	—	—	—	2	—	—	—	—	—	—	—	—	5	—	—
March 7 ...	27	9	1	5	—	—	66	1	—	—	1	—	—	—	—
May 22 ...	2	—	1	—	—	—	—	—	—	—	2	2	—	11	1
July 18 ...	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
August 29 ...	2	—	—	7	—	—	—	1	20	—	—	9	3	—	—
December 21	—	—	112	—	2	14	—	—	—	—	—	—	3	—	5
Totals ...	39	13	114	19	3	14	74	5	20	1	5	12	11	11	6

In considering the influence of lunar changes on the occurrence of accidents, Table V. shows the relation of explosions to the syzygies (the explosion represented by unity being placed in the position it occupies in relation to the centre of the syzygy) arranged according to the Metonic cycle (19 years). In the table, PL indicates full moon and NL new moon.

TABLE V.—INFLUENCE OF LUNAR CHANGE, AND RELATION OF EXPLOSIONS IN FRANCE TO THE CENTRE OF THE SYZYGY.

Cycle.		Explosions in France.														
1-1821, 1840, 1859, 1878	PL ...	0	1	1	0	3	1	0	6	0	0	2	1	1	3	0
	NL ...	1	5	2	0	1	1	2	0	1	2	0	1	3	2	2
2-1822, 1841, 1860, 1879	PL ...	1	1	0	3	1	0	3	3	2	1	0	1	3	3	2
	NL ...	1	2	1	2	1	0	2	1	2	2	2	1	0	2	1
3-1823, 1842, 1861, 1880	PL ...	1	1	0	1	2	0	3	2	4	1	2	0	3	0	2
	NL ...	1	2	1	2	3	4	1	1	2	2	3	1	2	2	1
4-1824, 1843, 1862, 1881	PL ...	0	1	0	5	2	2	2	1	1	3	2	2	1	0	0
	NL ...	0	0	3	0	1	1	4	0	1	1	1	1	1	2	1
5-1825, 1844, 1863, 1882	PL ...	2	5	3	3	0	0	1	2	2	3	2	1	0	1	0
	NL ...	0	0	1	2	3	1	0	0	1	0	2	0	1	0	0
6-1826, 1845, 1864, 1883	PL ...	1	2	2	1	0	0	3	0	4	2	1	1	0	1	1
	NL ...	1	0	2	1	0	1	0	1	1	0	0	3	2	2	2
7-1814, 1817, 1833-1836, 1852-1855, 1871-1874, 1890, 1891	PL	6	8	6	9	3	7	5	8	6	12	4	8	7	8	6
	NL	4	10	6	7	9	8	1	4	2	4	4	7	8	3	5
8-1818-1820, 1837-1839, 1856-1858, 1875-1877	PL	2	11	2	6	4	2	6	2	3	3	4	7	5	3	3
	NL	8	2	4	8	6	10	3	7	8	9	4	5	6	8	2
		Explosions in France and Belgium.														
9-Jan. to April, 1863-1883 and Sept. to Dec., 1863-1878	PL	6	15	11	10	7	7	10	12	10	12	8	6	10	9	5
	NL	8	16	9	15	12	4	5	5	6	10	10	7	14	13	6
10-Aug. to Dec., 1879-1883	PL	0	0	2	2	2	3	4	0	3	1	4	1	1	2	0
	NL	2	0	2	1	0	2	1	3	1	2	5	0	0	3	0
Totals	PL	19	45	27	40	24	22	37	36	35	38	29	28	31	30	19
	NL	26	37	31	38	36	32	19	22	25	32	31	26	37	37	20

The symmetry and compensation noticeable in seismic convulsions is also apparent in Table V., maximum figures for PL being coincident with minima for NL in any one year. The effect of the new moon is less than that of the full moon, and the accidents are more evenly spread over the 15 days' period. Generally speaking, the figures increase on the sixth day before the syzygy and on the fifth and sixth days after, thus agreeing with the laws of volcanic activity.

The effect of the conjunction of a boreal lunestice with the annual change was well shown in the years 1876 and 1895, the Terrenoire colliery-explosion (186 deaths) occurring on February 4th, three days anterior to the annual change, and a number of storms, etc., at the same period of the former year.

The recurrence of seismic and kindred phenomena at intervals of 16 years is gone into by the author, who refers to a previous treatise on this subject, and Table VI. is drawn up with a view to demonstrating the influence of the same cycle on the issue of fire-damp.

TABLE VI.—EXPLOSIONS (N) AND VICTIMS (V) IN BELGIUM IN CYCLES OF 16 YEARS (1831-1878).

Years.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	Totals.	Annual Averages.
1831 to 1846	N	6	3	4	6	9	3	4	14	13	18	13	11	9	7	10	10	140	8
	V	45	9	36	52	75	34	7	92	135	79	92	37	18	48	105	46	910	56
1847 to 1862	N	9	7	8	5	3	9	2	7	12	8	5	4	5	10	6	5	105	6
	V	87	41	43	90	23	130	12	39	64	79	19	37	20	46	45	79	854	53
1863 to 1878	N	8	6	5	9	3	4	7	7	5	9	9	9	6	5	5	10	107	6
	V	63	51	78	19	46	62	27	32	72	49	27	70	186	9	9	19	819	51

On grouping the elements of Table VI. into quadrennial periods, we obtain the results recorded in Table VII., showing that the largest number of explosions, etc., occur at the first and last years of the whole series of quadrennial periods taken together. Of the individual series, the third furnishes the greatest number (116), and this is worthy of note in that the first year of this series is the bi-quadrennial, a year of some importance in the cycle of volcanic phenomena; the average number of victims in this series is, however, smaller than in the others, showing a diminution in the intensity of the forces at work.

TABLE VII.—EXPLOSIONS AND VICTIMS IN BELGIUM IN QUADRENNIAL PERIODS.

A. Explosions.					B. Victims.					C. Number of Victims per 10 Average Explosions				
1.	2.	3.	4.	Totals.	1.	2.	3.	4.	Totals.	1.	2.	3.	4.	Totals
23	16	17	20	76	195	101	152	161	609	85	63	90	80	318
15	16	13	28	72	144	226	46	163	579	96	141	35	58	330
30	35	27	24	116	271	207	138	144	760	90	59	51	60	260
20	22	21	25	88	224	103	159	144	630	112	47	76	58	293
88	89	78	97	352	834	637	495	612	2.578	383	310	252	256	1,201
Annual average				22	Annual average				161	Annual average				75

Other tables grouping the results of the accidents into series containing over 5 killed, more than 10 injured and above 10 killed and injured combined, as well as statistics of accidents that occurred in French mines from 1815 to 1878, are also

given (Tables VIII. and IX.) with the idea of explaining more fully the relative intensity of the explosions in each year of the quadrennial period, and to show that the law of periodicity is generally applicable.

TABLE VIII.—NUMBER OF EXPLOSIONS IN BELGIUM ANNUALLY RESULTING IN AT LEAST:—

	5 Killed.				5 Injured.				10 Victims.			
1851-1854 ...	1	2	0	1	0	2	1	0	1	2	0	1
1855-1858 ...	2	1	0	2	1	5	1	1	2	3	0	1
1859-1862 ...	0	2	2	4	1	2	2	3	1	1	2	3
1863-1866 ..	1	1	2	0	1	4	0	0	2	1	1	0
1867-1870 ...	1	1	1	0	3	0	0	3	1	1	0	0
1871-1874 ...	2	4	1	3	1	1	0	5	2	1	0	2
1875-1878 ..	2	0	0	0	1	0	0	1	2	0	0	0
Totals ...	9	11	6	10	8	14	4	13	11	9	3	7
Victims corresponding to these numbers	264	235	89	112	101	103	31	98	367	277	93	150
Averages ...	29·3	21·3	14·8	11·2	12·6	7·3	7·5	7·5	33·1	31·7	31·0	21·4

TABLE IX.—EXPLOSIONS IN FRANCE DURING THE FOUR 16 YEARS' PERIODS FROM 1815 TO 1878.

Explosions					Victims.					Victims per 10 Mean Explosions.				
1.	2.	3.	4.	Totals.	1.	2.	3.	4.	Totals	1.	2.	3.	4.	Totals
30	27	38	45	140	98	87	157	103	445	33	33	41	25	132
34	50	51	58	193	262	145	178	187	772	77	30	35	33	175
41	53	53	74	221	258	171	127	173	729	63	33	25	23	144
42	36	50	32	160	110	99	211	80	500	25	28	43	25	121
147	166	192	209	714	728	502	673	543	2,446	198	124	144	106	572

The figures given in Table IX. (France) may be grouped into quadrennial periods as was done with the Belgian statistics, as shown in Table X. Thus

TABLE X.—EXPLOSIONS AND VICTIMS IN FRANCE IN QUADRENNIAL PERIODS.

Number of Killed.					Number of Injured.					The Number of Injured per 10 Killed.				
1.	2.	3.	4.	Totals.	1.	2.	3.	4.	Totals.	1.	2.	3.	4.	Totals
49	27	68	27	171	49	60	89	76	274	10	22	13	28	73
160	55	98	81	394	52	90	80	106	328	3	16	8	13	40
184	102	49	76	411	59	69	77	97	302	3	7	16	13	39
49	226	124	31	430	61	69	88	47	265	13	3	7	15	38
442	410	339	215	1,406	221	288	334	326	1,169	29	48	44	69	190

arranged, we see that in France the number of killed exceeds that of the injured, whilst in Belgium the former number decreased from the first to the fourth quadrennial term, the number of injured on the contrary rising; further, that the central pair of 4 years' terms show, when united, larger totals than the outer pair. The

number of men injured in France per 10 killed averages 11⅝; this average is exceeded in the second, third, fourth, sixth, eighth, eleventh, twelfth, thirteenth, and sixteenth years; in the first, fifth, seventh, ninth, tenth, fourteenth, and fifteenth years—which are the notable years in the volcanic cycle—the proportion of killed to wounded is highest.

From the table of mining accidents of all kinds, except from fire-damp, occurring in Belgium from 1855 to 1886, published in the *Annales des Travaux Publics*, the author draws the following conclusions :—

The ratio of killed to injured, per 10 accidents, decreases from the first to the fourth year of the general quadrennial, the minimum being, however, at the middle of the quadrennial period; and when the proportion of killed is high in any one year that of the injured is correspondingly low.

One exception is noted in Belgium, wherein the fourth quadrennial year gave a maximum number of victims, namely, in the period 1863-1878, owing to the terrible explosion of December 16th, 1875, resulting in 122 victims. Even in this case, the fourth period only shows 5 victims more than the third. Another instance is exemplified in France for the period 1847-1862, but here again the excess of the fourth over the third quadrennial period is but slight.

Table XI. shows clearly the regular course of the 16 years' cycle in France and Belgium.

TABLE XI.—INFLUENCE OF THE 16 YEARS' CYCLE IN BELGIUM AND FRANCE.

Sixteen Years' Cycle.		Belgium. Quadrennial Periods.				France. Quadrennial Periods.			
		1.	2.	3.	4.	1.	2.	3.	4.
1815-1830	N ..	—	—	—	—	13	27	23	6
	V ..	—	—	—	—	38	56	91	42
1831-1846	N ...	19	26	55	36	13	24	23	21
	V ...	142	208	353	217	72	65	102	46
1847-1862	N ...	29	21	29	26	31	46	84	71
	V ...	261	204	199	190	84	161	206	214
1863-1878	N ...	28	21	32	26	83	96	91	62
	V ...	211	165	218	223	251	490	320	196

NOTE.—N is the number of explosions, and V the number of victims.

The author lays it down as a principle fully established by the evidence, that the severity of the fire-damp explosions is usually greatest at the quadrennial years, decreasing from the first to the fourth year of each period, with, however, a tendency to increase again in the last year, so far as concerns the number of explosions. He considers that the attempted explanation of the cause of these explosions by the assumption that the gas is contained in "pockets" in the coal and becomes liberated in the course of working, is quite out of the question unless it be also assumed that the number of these pockets so exposed increases in certain years and on particular days in each year, which is hardly probable.

In examining the official figures of mining accidents in Belgium, from 1821 to 1879 (*Annales des Travaux Publics*, vol. xxxviii., page 120), in connexion with the influence of magnetic coincidences, it is found that the number of explosions occurring in the years of principal coincidences, together with the two years preceding and following, each amount to :—

A. Explosions : 108 ... 106 . 107 ... 114 ... 125

Out of 16 such coincidences, two only (1838 and 1863) are irregular, in that the central number exceeds that on either side, and must be considered as "disturbed." Separated on this basis we have :—

2 disturbed coincidences :	9	...	9	...	22	...	19	...	23
14 regular coincidences :	99	..	97	...	85	...	95	...	102

As a rule, the number of accidents is lowest at the central year, but the number of victims is, on the contrary, abnormally high, thus agreeing with the effect of the quadrennial year. In the case of the secondary coincidences, however, although the number of accidents is greater than in the intermediate years, the number of victims does not increase in proportion, being almost constantly exceeded by the latter years : the most intense of the accidents being apparently produced within the period occupied by the quadrennial meridian, in traversing the 90 degrees preceding, and following the principal coincidence. This is independent of the influence of the fixed 16 years period, which causes exceptions to the rule, such as the accident at Monceaux-les-Mines, due to this influence and not to any conjunction of the quadrennial and secular periods.

The coincidence of March, 1892, confirms this principle in a striking manner. The occurrence of serious accidents, dated from about the middle of the previous year, increasing in quantity and severity up to March, 1892, and lasting another twelve months, concluding with the earthquakes in Greece, and various mining accidents during the first quarter of 1893. In 1894, the year of secondary coincidence, there were few accidents, but those occurring were of a serious nature, after which quiet was restored for a while. The next principal coincidence occurs at the end of April, 1896.

The results, obtained by an examination of French statistics, agree with the foregoing, only 4 coincidences being disturbed out of 19, and they occurred during the winter. Between 1829 and 1875 no disturbance occurred, the year of coincidence exhibiting throughout the highest number of victims from a small number of explosions, and the intermediate years the predominating number of slight accidents. C. S.

UTILIZATION OF FIRE-DAMP FOR LIGHTING PURPOSES.

La Récupération des Gaz grisouteux au Puits Saint-Guillaume, à Mährisch-Ostrau, Moravie. *By* H. Schmerber. *Le Génie Civil*, 1896, *vol. xxix., pages* 414-415.

A few years ago, in proving one of the coal-seams in the Moravian-Ostrau coal-field, a heading was driven in the seam for a length of about 350 feet (105 metres), in the course of which a constant and abundant disengagement of fire-damp occurred ; and the idea was then conceived of collecting this gas. Accordingly, the entrance of the heading was closed by a thick wall coated with cement, which imprisoned the gas ; and a pipe (2 inches in diameter) was arranged at the top of the wall, and led up to the surface by the Wilhelm shaft, terminating in a receiver, made from a boiler of 53 cubic feet (1·5 cubic metres) capacity, near the explosives-testing station. The receiver was provided with a water-gauge and scale which showed, at a glance, the exact extent to which it was filled or emptied.

Soon after the stopping in the heading was finished, a certain pressure of gas was noticed, which, however, did not exceed that corresponding with $\frac{3}{8}$ inch (8 to 10 millimetres) of water, because, notwithstanding all the care taken to ensure tightness, there was constant and considerable escapes of gas, not only at the wall but also through the coal. It was afterwards found that the pressure was practically constant, notwithstanding the considerable quantities of gas used ; and this

pressure was only to a very slight extent influenced by variations of the barometer. The pressure of the gas in the pipe attained about 3·54 inches (90 millimetres) of water at the surface; and this difference of pressure, which might at first glance appear abnormal, is explained, first by the great difference of altitude, 656 feet (200 metres), between the bottom of the shaft and the surface; and secondly by the difference in the specific gravity of the two gases, that of the fire-damp in the pipe and that of the air in the shaft.

The gas might have been allowed to pass by its own pressure into the receiver, which, however, it was preferred to fill by aspiration with water, because in this manner gas might be introduced, not only of great pressure, but also of slight pressure or none at all.

In order to have a considerable quantity of gas constantly at command, two other receivers, like the first and of the same capacity, were put up and connected with it. Thanks to the precautions taken to prevent the entrance of air, the variations in the methane content did not exceed 7 or 8 per cent., the gases experimented with having a content varying from 85 to 93 per cent. of methane. Besides serving for experiments, the gas was used for lighting, being made to bubble through lime-water, on leaving which it had a tolerably high illuminating power. J. W. P.

COMPOSITION OF FIRE-DAMP.

Étude sur la Composition du Grisou. By Th. Schloesing, Jun. *Annales des Mines*, 1897, *vol. xi., pages* 5-37.

In a previous Abstract,* the results of several analyses of fire-damp, by Mr. Schloesing and the conclusions he arrived at concerning the combustible constituents thereof are given. In this paper, Mr. Schloesing reproduces these analyses and conclusions, and adds the result of investigations concerning the non-combustible constituents of fire-damp. For this purpose, samples of fire-damp were obtained, not by displacement of water, but by aspiration of gas under pressure from the solid coal. Nitrogen is always found in fire-damp, but in very variable proportion. In seven samples, the extreme proportions were 0·74 per cent. and 30 per cent. The author discusses the probable source of this nitrogen, and thinks it difficult to ascribe it to the nitrogenous constituents of the vegetable matter, from which the coal was formed, because, in slow decompositions reproduced in the laboratory, such great variations are not observed, nor, especially such large volumes of nitrogen liberated in proportion to the methane formed. It was, therefore, natural to think of the air as a possible source of the nitrogen in fire-damp, and the author suggests that the distinction between nitrogen proceeding from vegetable matter and nitrogen from the air might be founded on the presence of argon in the nitrogen. In preliminary trials, made with a mixture of several samples of nitrogen from fire-damp, 1·1 per cent. of argon was found. Samples of fire-damp, liberated under considerable pressure, were obtained, in one of which argon was found in practically the same proportion (1·18 per cent. corrected) as in atmospheric nitrogen (1·19 per cent.). In other samples, the proportion of argon to nitrogen varies from 1·09 to 3·28 per cent. The author thinks that if the nitrogen in these fire-damps was derived from the atmosphere, the air containing it must have been imprisoned in the coal about the time when the fire-damp was formed, and he refers to it as "fossil air." The possibility of atmospheric nitrogen being introduced, dissolved in water by percolation, is also suggested. The method of analysis is fully described.

* *Trans.*, vol. xi., page 611.

TABLE I.—RESULT OF EXPERIMENTS.

Source of the Samples of Fire-damp.	Pressure under which the Fire-damp was liberated in Water Column.	Volumes at 0° Cent. and 760 Millimetres.			Nitrogen with Argon in 100 Parts of Fire-damp. A.	Argon in 100 Parts of Fire-damp. B.	Argon in 100 Parts of Nitrogen and Argon. C.
		Fire-damp furnishing Nitrogen with Argon.	Nitrogen with Argon extracted.	Argon.			
	Centi-metres.	Litres.	Cubic Centi-metres.	Cubic Centi-metres.	Per Cent.	Per Cent.	Per Cent.
Anzin ...	400	3·5	634·0	20·78	18·1	0·594	3·28
Bessèges ...	4 to 5	4·9	186·7	3·04	3·8	0·064	1·63
Firminy ...	16	18·4	135·8	2·27	0·74	0·012	1·67
Liévin ...	70	5·5	437·1	9·71	8·0	0·166	2·22
Plat de Gier .	75	1·9	592·9	10·85	30·0	0·601	1·83
Ronchamp ...	8	9·1	255·4	2·79	2·8	0·031	1·09
Saint Etienne	600	15·5	497·5	5·81	3·2	0·037	1·17

An analysis of the gas liberated with such dangerous force and suddenness in the Rochebelle mines is as follows:—

Nitrogen and argon	1·14
Methane	0·73
Carbonic acid	98·13

Table II. indicates the presence of argon in the Rochebelle gas.

TABLE II.—ANALYSIS OF GASES.

Volume at 0° Cent. and 760 Millimetres.			Nitrogen with Argon in 100 Parts of Gas treated.	Argon in	
Rochebelle Gas treated.	Nitrogen with Argon extracted.	Argon.		100 Parts of Gas treated.	100 Parts of Nitrogen and Argon.
Litres.	Cubic Centimetres.	Cubic Centimetres.	Per Cent.	Per Cent.	Per Cent.
20·0	2228·9	4·29	1·14	0·021	1·87

The analyses of samples of coal for the detection of argon resulted in obtaining from 22 grammes of St. Etienne coal (undried) 243 cubic centimetres, or 0·304 gramme of nitrogen (1·38 per cent. by weight), and from 18·3 grammes of coal from the Plat de Gier, 196 cubic centimetres or 0·245 gramme, was obtained (1·34 per cent. by weight). Treated for argon, a residue of 0·05 cubic centimetre was obtained, or only one-fiftieth of the argon which would have been furnished by atmospheric nitrogen, and this residue might represent impurities from the reagents employed or small quantities of air in the apparatus. The coals examined contained at the most, if they contained any, $\frac{1}{200000}$ of an element comparable to argon.

The author further discusses the probable source of the nitrogen and argon in fire-damp, which, he thinks, cannot be the coal, but, without attaching great importance to the hypothesis, that they proceed from the atmosphere.

W. N. A.

ESTIMATION OF METHANE IN THE AIR OF MINES.

Ueber die Bestimmung des Methans in der Grubenluft. By Ed. Hankus. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 548-549.

The result of some 200 analyses of air taken from the same part of a coal-mine showed that, as a rule, the amount of methane present became larger as the barometer fell, and *vice versa*, the samples which contained 1 per cent. of methane when the barometric pressure was 29·547 to 29·725 inches (750·5 to 755 millimetres), being found to contain 1·2 per cent. when the pressure receded to 28·741 to 28·937 inches (730 to 735 millimetres). Some exceptions were noticed, but were attributed to fluctuations in the air-current.

From other experiments, it appears to be immaterial, so far as methane is concerned, whether the analysis of pit-air is performed as soon as the sample is taken or after several days' storage. On the other hand, the carbon dioxide becomes to some extent dissolved in any water present in the sampling vessel, and consequently the results for this gas may come out rather too low.

A more important influence, however, is exerted on the results by the presence of a greenish-brown sediment of organic matter in the storage-vessel. Such matter may be deposited from the water used to fill the vessel, or be contained in the pit-air; but whatever its source, the result of its presence is the gradual decomposition of the methane, and a corresponding increase in the carbon dioxide in the sample. In one instance, the initial quantities of 1 per cent. of methane and 0·2 per cent. of carbon dioxide were modified in 4 hours to 0·75 per cent. and 0·25 per cent. respectively, and the whole of the methane had disappeared in 20 hours. Similar results were obtained in other cases, the rate of decomposition varying in proportion to the amount of organic deposit present. To avoid such a *contretemps*, the author recommends that none but thoroughly-cleaned glass bottles should be employed for collecting and storing samples of such air and gas. C. S.

METHODS OF ASCERTAINING WHETHER FIRE-DAMP BE PURE METHANE.*

Original paper. By J. Coquillion.

The gas disengaged from coal, designated by the name of fire-damp, may be either pure methane or a mixture of that gas with other gases. Its purity can be ascertained by two methods, that generally employed being the method by direct combustion. A few cubic centimetres (16 cubic centimetres = 1 cubic inch) are introduced into a eudiometer with sufficient air to ensure the completeness of the combustion; and an electric spark is made to pass through the mixture. The diminution of volume owing to the formation of the water-vapour, which is condensed, is observed; and then the carbonic acid is absorbed by potash, when a fresh diminution of volume will ensue, equal to half the former if the gas in question be pure methane.

The second method consists in decomposing the methane by means of water-vapour, in accordance with the formula:—

$$CH_4 + H_2O = CO + 6H$$
$$1 \text{ vol.} \qquad = 1 \text{ vol.} + 3 \text{ vol.}$$

With this object, from 5 to 6 volumes of nitrogen are first introduced into a graduated test-tube, the sides of which have been carefully wetted. From 3 to 4 volumes of methane are then added, the addition of nitrogen not being indispensable; and then the U-burner is introduced into the tube, which rests upon mercury.

* *Trans. Fed. Inst.*, vol. xiii., page 60.

In order to form this U-burner, a piece of glass tube about 8 inches (2 decimetres) long and from 0·08 to 0·12 inch (2 to 3 millimetres) in diameter, receives a platinum or palladium wire, about 0·008 inch (0·2 millimetre) in diameter, projecting about 2 inches (from 4 to 5 centimetres) beyond each end. The glass tube is then bent into the form of a letter U, having one arm, that to be introduced into the graduated tube, rather shorter than the other, in order to facilitate the manipulation. The metal wire, on leaving this arm, forms a small spiral a few millimetres above the orifice of the tube, and then descends, parallel with this tube, for rather more than 1 inch (from 2 to 3 centimetres), being wound round the glass, while the other end of the metal wire is left free. To render the wire incandescent, one of the poles of a battery, or any other source of electricity, is plunged into the reservoir of mercury, while the other is inserted into the arm of the burner which remains outside the graduated tube.

After the metal wire is made incandescent, and when the volume of gas no longer increases, the burner is withdrawn. Sufficient time having been allowed for the gas to cool, it will be found, on observation, that 1 volume of methane has increased to 4 volumes, the increase being thus 3 volumes.

There would be great interest in ascertaining whether, in different collieries, the gas disengaged from the coal is more or less pure, and consequently more or less dangerous. J. W. P.

EXPERIMENTS WITH EXPLOSIVE MIXTURES.

Expériences sur les Mélanges explosifs. Original paper. By J. Coquillion.

Oxygen, when combining with hydrogen in a closed vessel, causes a detonation wellknown to chemists, who explain it in the following manner:—The steam which is formed, raised to a high temperature, suddenly drives the air before it, whence results a first shock; and this steam is condensed on the sides of the vessel, whereupon ensues the sudden entrance of air, which causes a second shock, following so closely on the former that the ear only perceives a single detonation.

With hydrocarbon gases (methane, ethylene, or acetylene) mingled with air or oxygen, the explanation is the same; but the products are different, as carbon dioxide and carbon monoxide are produced with a deposit of carbon if there be a deficiency of air or oxygen.

Detonations are easily caused, with suitable mixtures of air and explosive gases, by means of the electric spark, or by platinum or palladium wires raised to a white heat. With 1 part of fire-damp and about 6 parts of air, each electric spark causes a series of slight explosions; but, on increasing the quantity of air, only one detonation, stronger and more distinct, is obtained, while with 16 parts of air slight explosions are again obtained.

With platinum and palladium wires brought to a white heat, the limits of explosion are no longer the same; and the palladium wire causes much slighter detonations than platinum wire. While the electric spark determines a detonation almost immediately, the platinum and palladium wires only bring it about after a few tenths of a second from their being made incandescent.

Ethylene and acetylene produce stronger detonations than methane. A few experiments afford the impression that the gases found in different collieries possess explosive properties which vary with their origin; and there would be great interest in investigating the circumstances under which they are manifested, and this in connexion with coal-dust, which plays an important part in explosions, as has been shown by Mr. W. Galloway's experiments. J. W. P.

EXPLOSIBILITY OF FIRE-DAMP BY ELECTRIC CURRENTS.

Recherches sur l'Explosion des Mélanges grisouteux par les Courants électriques. By H. Couriot *and* J. Meunier. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvi., pages* 750-753.

The authors, first of all, point out that there are three classes of electric phenomena which may have some action on explosive mixtures:—(1) Incandescence of a conducting wire, such as that of an electric lamp; (2) electric sparks, especially those due to breaking of the current; and (3) the voltaic arc formed between two carbons. They studied all these classes of phenomena, but they confine their present report to the results experimentally obtained in regard to the first two.

It was found impossible to ignite a current of fire-damp, containing 80 per cent. of methane, either in directing it against a metallic wire heated to incandescence by an electric current, or upon the current-breaking spark which arises on the fusion of the wire. The same experiment, repeated with ordinary illuminating-gas, determined immediate ignition. But, if a substance in flames be present, such as a lighted match, the fire-damp current ignited in the same way as the coal-gas.

In their further experiments, the authors no longer dealt with currents of gas, but led the explosive mixtures into a recipient over a pneumatic trough, and then, by means of an electric current, heated to redness a metallic wire (of varying lengths and diameters) placed in the midst of the gas. This wire was kept in place by two metallic conductors (various metals were tried), curved in such wise as to be easily brought into the glass jar. The ends alone of the conductors were left bare, so as to permit of the connecting wire being wound round them. Heating to redness soon resulted in the fusion of the wire, accompanied by a current-breaking spark. The following conclusions are arrived at:—

Electricity causes only one apparent phenomenon in the midst of a detonating mixture of fire-damp—that of explosion.

Metallic wires heated to redness by an electric current are powerless to determine detonation of even the most explosive mixtures. As long as the incandescent wire does not break, no explosion takes place. This explosion is due simply to the current-breaking spark; thus it may take place on the fusion of lead wires, which melt far below red heat. The sparks which are often produced between the incandescent wire and the metallic conductors do not cause explosion.

The combustion of the mixture is complete so long as the proportion of oxygen present is not less than 5·5 per cent. The most easily explosive mixtures are those which contain 9·5 per cent. of methane. The slightest change in the composition of the mixtures affects their liability to explode. L. L. B.

REGULATION OF THE EXPLOSIVES TO BE USED IN FIERY MINES AND IN DUSTY MINES WHERE DUSTS ARE INFLAMMABLE.

Explosifs de Sûreté; Calcul de la Température de Détonation. Annales des Mines, Recueil de Lois, Décrets, Arrêtes et autres Actes, 1896, *vol. v., pages* 466 *to* 468.

Paris, *August 29th*, 1896.

To the Prefect of ———.

Acting in accordance with a circular of one of my predecessors of August 1st, 1890,* you have imposed on each fiery mine and each dusty mine whose dusts are inflammable in your department the use of safety-explosives, under conditions stipulated in the said circular. The temperature of detonation of these explosives

* *Report of the French Commission on the Use of Explosives in the Presence of Fire-damp.* Translated by Messrs. W. J. Bird and M. Walton Brown, page 159

must be below values determined according to the circumstances, and this temperature must be estimated by a calculation and in accordance with co-efficients that the said circular indicated for a number of substances contained in the model prefectoral decree.

Since that date further experiments have permitted the determination of the quantities of heat produced by decomposition and the specific heats with a much greater exactitude.

Moreover, it has appeared useful to give more extended co-efficients, so as to allow of the control of the temperatures of detonation of a greater number of explosives.

Consequently, in accordance with the indications which have been supplied to me by the Fire-damp Commission, I have decided that the two tables which are annexed to the model of the prefectoral decree attached to the circular of August 1st, 1896, should be replaced by the two attached tables prepared from those published in the *Mémorial des Poudres et Salpêtres** and *Théorie des Explosifs*, by Mr. Emile Sarrau.

It will be unnecessary for you to make new decrees modifying those which you have already made, containing different values of the quantities of heat and of specific heat. It will be sufficient if you send copies of the present circular to all workers of mines concerned, who should be advised to consider it as modifying in an appropriate manner your former prefectoral decree.

You are desired to acknowledge to me the receipt of the present circular, which I have addressed in duplicate direct to the inspectors of mines.

The Minister of Public Works,

TURREL.

TABLE I.—QUANTITIES OF HEAT PRODUCED BY THE FORMATION OF SUBSTANCES DEDUCED FROM THEIR ELEMENTARY COMPOSITION, THE SUBSTANCES AND THEIR COMPOUNDS BEING TAKEN IN THEIR ACTUAL CONDITION AT a + 15 DEGREES.

Substances.	Formulæ.	Grammes.	Quantities of Heat. Calories.
Hydrogen compounds—			
Hydrochloric acid	HCl	= 36·5 ...	+ 22·0
Water (vapour)	H_2O	= 18·0 ...	− 58·2
Water (liquid)	H_2O	= 18·0 ...	+ 69·0
Sulphuretted hydrogen ...	H_2S	= 34·0 ...	+ 4·8
Ammonium (gas)	NH_3	= 17·0 ...	+ 12·2
Oxygen and sulphur compounds—			
Nitrogen monoxide (gas) ...	N_2O	= 44·0 ...	− 20·6
,, ,, (liquid)	N_2O	= 44·0 ...	− 18·0
Nitrogen dioxide	NO	= 30·0 ...	− 21·6
Nitrogen tetroxide (liquid)...	NO_2	= 46·0 ...	+ 1·8
Nitric acid (liquid)	HNO_3	= 63·0 ...	+ 41·6
Carbon dioxide	CO_2	= 44·0 ...	+ 94·3
Carbon monoxide	CO	= 28·0 ...	+ 26·0
Sulphur dioxide	SO_2	= 64·0 ...	+ 69·2
Carbon disulphide (gas) ...	CS_2	= 76·0 ...	− 19·0
,, ,, (liquid)...	CS_2	= 76·0 ...	− 25·4
Nitrates—			
Ammonium nitrate	NH_4, NO_3	= 80·0 ...	+ 88·6
Potassium nitrate	KNO_3	= 101·0 ...	+ 119·0
Sodium nitrate	$NaNO_3$	= 85·0 ...	+ 110·6

* 1894, vol. vii., page 231 *et seq.*

Substances.	Formulæ.	Grammes.	Quantities of Heat. Calories.
Chlorates—			
Potassium chlorate	$KClO_3$	= 122·5 ...	+ 93·8
Sodium chlorate	$NaClO_3$	= 106·5 ...	+ 84·8
Carbonates—			
Potassium carbonate ...	K_2CO_3	= 138·0 ...	+ 278·8
Sodium carbonate	Na_2CO_3	= 106·0 ...	+ 274·8
Sulphates—			
Potassium sulphate	K_2SO_4	= 174·0 ...	+ 344·2
Sodium sulphate	Na_2SO_4	= 142·0 ...	+ 328·0
Sulphides—			
Potassium sulphide ...	K_2S	= 110·0 ...	+ 103·4
Sodium sulphide	Na_2S	= 78·0 ...	+ 89·2
Chlorides—			
Potassium chlorides... ...	KCl	= 74·5 ...	+ 105·7
Sodium chloride	NaCl	= 58·5 ...	+ 97·9
Hydrocarbon compounds—			
Acetylene	C_2H_2	= 26·0 ...	— 58·1
Ethylene	C_2H_4	= 28·0 ...	— 14·6
Ethane	C_2H_6	= 30·0 ...	+ 23·3
Methane (fire-damp) ...	CH_4	= 16·0 ...	+ 18·9
Benzol (gas)	C_6H_6	= 78·0 ...	— 11·3
,, (liquid)	C_6H_6	= 78·0 ...	— 4·1
Naphthalene (liquid) ...	$C_{10}H_8$	= 128·0 ...	— 27·4
,, (solid)	$C_{10}H_8$	= 128·0 ...	— 22·8
Phenols, alcohols, etc.—			
Phenol (liquid)	C_6H_6O	= 94·0 ...	+ 34·5
,, (solid)	C_6H_6O	= 94·0 ...	+ 36·8
Glycerine (liquid)	$C_3H_8O_3$	= 92·0 ...	+ 161·7
Mannite	$C_6H_{14}O_6$	= 182·0 ...	+ 320·0
Cellulose (cotton)	$C_{24}H_{10}O_{20}$	= 648·0 ...	+ 921·6
Ethers—			
Ethyl alcohol (gas)	C_2H_6O	= 46.0 ...	+ 51·4
Ether (gas)	$C_4H_{10}O$	= 74·0 ...	+ 62·8
Nitric ether	$C_2H_5NO_3$	= 91·0 ...	+ 48·7
Nitro-glycerine	$C_3H_53(NO_3)$	= 227·0 ...	+ 94·5
Nitro-mannite	$C_6H_56(NO_3)$	= 452·0 ...	+ 179·1
Gun-cotton—			
Endeca-nitric cellulose ...	$C_{24}H_{29}11(NO_3)O_9$	= 1143·0 ...	+ 631·0
Nono-nitric cellulose ...	$C_{24}H_{31}9(NO_3)O_{11}$	= 1053·0 ...	+ 681·0
Octo-nitric cellulose ...	$C_{24}H_{32}8(NO_3)O_{12}$	= 1008·0 ...	+ 706·0
Nitrogen compounds—			
Cyanogen (gas)	C_2N_2	= 52·0 ...	— 73·9
Fulminate of mercury ...	$HgC_2N_2O_2$	= 284·0 ...	— 63·5
Nitro-diazobenzol	$C_6H_5N_2NO_3$	= 167·0 ...	— 45·6
Picric acid	$C_6H_32(NO_2)O$	= 229·0 ...	+ 46·8
Picrate of ammonium ...	$C_6H_6O_7N_4$	= 246·0 ...	+ 80·1
Picrate of potassium ...	$C_6H_2KO_7N_3$	= 267·0 ...	+ 115·3
Nitro-benzol	$C_6H_5NO_2$	= 123·0 ...	+ 4·0
Dinitro-benzol	$C_6H_42(NO_2)$	= 168·0 ...	+ 13·0
Trinitro-benzol	$C_6H_33(NO_2)$	= 213·0 ...	+ 22·0

Substances.	Formulæ.	Grammes.	Quantities of Heat. Calories.
Nitrogen compounds—			
Nitro-naphthalene	$C_{10}H_7NO_2$	= 173·0 ...	− 14·7
Dinitro-naphthalene ...	$C_{10}H_62(NO_2)$	= 218·0 ...	− 5·7
Trinitro-naphthalene ...	$C_{10}H_53(NO_2)$	= 263·0 ...	+ 3·3
Potassium cyanide	KCN	= 65·0 ...	+ 29·4

TABLE II.—SPECIFIC HEATS (CALORIES) OF 1 GRAMME OF THE SOLID BODY.

Substances.	Specific Heats. Calories.
Barium carbonate	0·110
Potassium carbonate...	0·210
Sodium carbonate	0·270
Potassium sulphate	0·190
Sodium sulphate	0·229
Potassium sulphide	0·162
Sodium sulphide	0·228
Potassium chloride	0·173
Sodium chloride	0·213
Potassium cyanide	0·161
Silica	0·195
Wood charcoal	0·241

M. W. B.

DIMINISHING USE OF EXPLOSIVES IN BELGIAN COLLIERIES.

Emploi des Explosifs dans les Mines de houille de Belgique pendant l'Année 1895. *By* VICTOR WATTEYNE. *Annales des Mines de Belgique*, 1896, *vol. i., pages* 585-625.

By way of obtaining manageable figures for comparing the decrease in the use of explosives in Belgian collieries, the author has adopted the term "intensity of blasting" (*densité du minage*), which represents the quantities in kilogrammes of all kinds of explosives used in driving roads (ripping roof and floor) for every 1,000 tons of coal extracted multiplied by the mean thickness in metres of the seams worked. Belgian collieries are divided into four categories—non-fiery, slightly fiery (class i.), decidedly fiery (class ii.), and very fiery (class iii.)—each subject to different official regulations. Thus, the intensity of blasting in slightly fiery mines decreased from 29 in 1893 to 26 in 1894, but apparently rose to 27 in 1895; and in decidedly fiery mines it fell from 17 in 1893 to 15 in 1894, and 14 in 1895, while in very fiery mines these figures are 5, 4, and 3 respectively.

The new regulations as to explosives, which were promulgated by royal decree of December 13, 1895, mark an important era in the history of explosives consumption in collieries. Their main distinctive features are the interdiction (1) of the use of slow explosives (black powder, etc.,) for driving and enlarging roads (ripping roof and floor) in all mines decidedly fiery; (2) in the same mines, and for the same operations, of priming or firing methods that might project flame or ignited substances outside the shot-hole; (3) of all explosives without exception for the most dangerous case—that of driving and enlarging roads in fiery mines of all three classes; and (4) of blasting in dusty places. The regulations permit, however, the use of explosives for sinking shafts and driving cross-measure drifts.

The following are the considerations which led to the interdiction of explosives in the four different cases above-named:—

1.—The new Belgian regulations only forbid black-powder for ripping roof and floor because of its undoubted capability of igniting gassy or dusty mixtures; and preference is implicitly given to high explosives of such composition as emit, on detonating, but little flame capable of igniting fiery or gassy mixtures. Explosives may now be obtained which, if far from being absolutely safe, at any rate possess a considerable degree of security, especially if used judiciously, in moderate charges and well tamped.

2.—No improvements that may be introduced into the manufacture of explosives for suppressing the flame due to their deflagration or detonation will evidently be effective, if the method of priming or firing adopted be of itself capable of sending flame into the mine atmosphere. Other methods of firing, however, such as that by electricity, have already come into use, and are free from the above objections.

3.—Inasmuch as no explosive can yet, notwithstanding the improvements effected, be regarded as absolutely safe, blasting must always be dangerous in places where inflammable mixtures can exist or may form, whence the great restrictions introduced by the new regulations into the use of all explosives. These restrictions apply, for each class of mines, to certain points considered dangerous by their very position in the workings; and in this respect the Belgian regulations are more precise than most of those in other countries. Where, however, they are less explicit and, to a certain extent, less stringent than some of the latter, is in the conditions under which blasting is forbidden; and the "no fire-damp" of the regulations must be understood to mean such as may be detected by the lamp. The restrictions of 1895 may be suspended with previous permission, granted for a limited period but renewable.

4.—Now for the first time have measures been prescribed in Belgium against the danger of coal-dust; and their restriction to fiery mines is justified by the fact that, in that country, non-fiery mines are always but slightly, or not at all, dusty, while in scarcely any case is the dust they contain dangerous as regards inflammability. J. W. P.

FAVIERITE.

Les Explosifs de sûreté, leur Fabrication, leurs Propriétés et leurs Usages. By H. Schmerber. *Le Génie Civil*, 1896, *vol. xxx., pages* 100-104 *and* 115-117, *with drawings.*

If the chemical reaction between two substances be instantaneous and the products gaseous, formed at a very high temperature, and with great pressure, these substances constitute an explosive, which consists of two specific parts, viz., the supporter of combustible which determines combustion, and the combustible which supports it; the former supplies the latter with the oxygen necessary for its instantaneous combustion. Up to a few years ago, these two parts formed, in all the high explosives known, perfectly well-defined compounds; and the discovery of gun-cotton by Dr. Schönbein in 1845, that of nitro-glycerine by Prof. Sobrero in 1847, and especially its utilization as dynamite by Mr. Nobel in 1863, confirmed the idea that a true chemical combination was necessary to form a high explosive, this property, of being a well-defined compound, renders all these explosives very unstable, and therefore highly dangerous.

About 1873, Dr. Sprengel drew attention to the fact that safe and simple mixtures might be substituted for these dangerous combinations; and Major Favier undertook the long investigations which resulted in the introduction of the explosives bearing his name. Major Favier stated that in the detonation of nitrated

explosives there are two successive phases, the first which determines, by the action of an external energy, the dissociation of their elements, and the second, that during which these same elements, obeying their most intense affinities, disengage considerable quantities of heat, in consequence of which Major Favier arrived at the two following conclusions:—(1) Inasmuch as, in the detonation of nitrated derivatives, the original grouping of their atoms must be first destroyed, it is needless to incur the dangers which ensue from the fixation of the nitric elements on the hydrocarbons, while equally powerful explosives could be obtained by a simple juxtaposition of these same elements; and (2) it should be possible, by suitably increasing the force of the initial molecular shock necessary for determining the explosion of nitrated matters, to detonate substances which are stable under ordinary conditions. When these principles were once established, Major Favier fixed upon nitrate of ammonium as the substance determining the combustion, and for the combustible he gave preference to nitrated naphthalines, which substances were mixed so intimately that the dangers of true chemical combination were avoided, while the explosives were just as powerful as those formed by them.

Since the death of Major Favier, the manufacture of safety-explosives has been greatly improved; and the company which manufactures favierite in France supply six explosives, of which two are specially intended for dusty and fiery mines, their composition having been determined so that their detonation-temperature shall not attain 1,500° Cent. for the first and 1,900° Cent. for the second—temperatures adopted as limits by the French Fire-damp Commission for explosives that may be used in fiery mines for coal and rock respectively. The explosive for coal, which bears the name of *grisounite-couche*, is composed of 95½ parts of ammonium nitrate and 4½ parts of trinitro-naphthaline; and that for rock, designated *grisounite-roche*, of 91½ parts ammonium nitrate and 8½ parts dinitro-naphthaline, the respective temperatures of detonation (as calculated by Mr. Le Chatelier) being 1,445 and 1,875° Cent.

The author then describes the methods for producing the raw materials which enter into the composition of these safety-explosives, viz., nitrate of ammonium and nitro-naphthalines, and also their mixture (which in France is effected in the Government powder-mills), the putting up of the explosives into cartridges, their paraffining, packing, and the paraffining of the packets, which has more lately been adopted as an additional safeguard against damp.

Grisounite-couche, which detonates with greater difficulty than other explosives, on account of its slight content of matter supporting combustion, is charged loose into the cartridge-case, so as the more readily to respond to the action of the detonator; but the other explosives are compressed, with a view to increasing the density of the powder, and therefore diminishing the volume of the cartridge, while the core in contact with the fulminate is left pulverulent.

Some experimental trials made at Pavia on behalf of the Italian Minister for War showed that no explosion ensued through the impact of a falling weight, flattening a cartridge between sledge-hammer and anvil, the falling of a hundred cartridges from a height of 50 feet on to stone, or the passage over them of a train, while various tests have shown that favierite No. 1 exerts the same force as the strongest dynamite; and yet, notwithstanding its great stability, the explosive may be readily detonated with 15½ grains (1 gramme) of fulminate, though it is preferable to use double that quantity for grisounites. J. W. P.

UNDERGROUND DYNAMITE MAGAZINES.

(1). *Commission des Substances Explosives. Rapport sur les Expériences de Blanzy: Étude des Conditions d'Établissement des Dynamitières Souterraines. Annales des Mines*, 1897, *vol. xi., pages* 89-119, 6 *illustrations and* 1 *plate.*

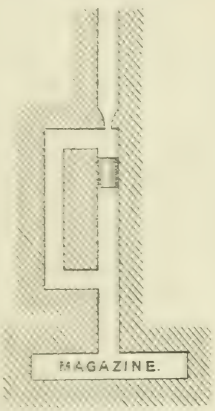
(2). *Commission du Grisou. Établissement des Dynamitières Souterraines: Rapport présenté a la Commission. By* — LEDOUX. *Ibid., pages* 517-543, *and* 6 *illustrations.*

Dynamite magazines, built, as usual, above ground, are open to a number of objections; thus they must be placed so far from inhabited buildings as to make it difficult or impossible to keep proper watch on them. The daily transport of explosives from the magazine to the mines presents some danger, especially in winter time, while in populous districts it is not easy to find a suitable site. Attempts have, therefore, been made to store explosives below ground, and in many countries it has been the practice thus to store 1½ to 2 cwts. of dynamite. In some cases it has been found desirable to store larger quantities, up to 2 tons, of dynamite underground, and the Fire-damp Commission was accordingly instructed to investigate this subject.

It was found, in the first place, that the dynamite should not be packed too closely, and that the minimum cubical contents of the magazine can be determined from the maximum weight that it is to contain, by the approximate formula, $V = 1{\cdot}6\ W$, where W is the weight of dynamite in pounds, and V is the minimum volume of the magazine in cubic feet. The boxes of dynamite should also be laid in a single row end to end, and not piled one above the other, so that the explosive force of the dynamite may not be localized. The depth below the surface or the distance that should separate the magazine from the nearest workings may be calculated from the formula—

$$R = 5{\cdot}8 \sqrt[3]{\frac{a}{b}\,C},$$

where R is the limit within which the shattering effect of the explosive will be felt, C is the weight in pounds of the explosive, a is a coefficient depending on the nature of the explosive, equal to 0·45 for black powder, 1·14 for dynamite No. 1 with 75 per cent. of nitroglycerine, and 1·60 for gelatine dynamite; whilst b is a coefficient depending upon the nature of the surrounding rock, being 1·25 for loose ground, 1·5 for ordinary ground, and 4 for rock. The limit as given by this formula should be doubled for the sake of safety.



The chief danger is due to the enormous pressure that the wave of the explosion would produce throughout the workings, and to the deleterious gaseous products of the explosion which would be driven into the workings of the mine. Preliminary experiments had shown that the only satisfactory method of obviating these dangers was by some means of automatically closing the communication between the magazine and the mine, as soon as an explosion occurs in the former. The method tried first, on a small scale, was the following:—The communication consists of a drift, circular in cross section; at a given point this drift is constricted to two-thirds of its diameter. On the magazine side of the constriction, and several feet away, is placed a stout plug that exactly fills the circular drift. Between the constriction and the plug there is a short drift at right angles to the main drift; from this

short drift another is driven, parallel for some little distance to the main drift, towards the magazine, and this parallel drift is again connected with the main drift by a short cross drift. There is thus a road always open between the magazine and the mine by means of the two cross drifts and the short parallel drift, which form a by-pass, whilst the straight main drift remains permanently obstructed by the plug. Should an explosion occur, the explosive wave will be propagated, and the products of explosion will tend to escape both along the straight drift and through the by-pass drift; in the former, the immediate effect will be to propel the plug against the constriction, which is arranged so as to form a seat for it, whilst so much more time will be occupied in traversing the by-pass drift with its two right-angled bends that the plug will have already been driven against its seat, and thus have effectually blocked all communication between the magazine and the mine. On a small scale this method answered well. Further experiments showed that a dynamite-magazine should be ⊤-shaped in plan, the leg of the ⊤ forming the means of communication with the workings. It is found that in this way, from whatever point in the magazine the explosion may start, the pressures due to it are at a maximum at the ends of the head of the ⊤ which become nodal points, whilst its centre forms a ventral segment, at which the pressure due to the explosion is a minimum.

The system was tried at Blanzy; a drift was driven into the face of a quarry for a length of 160 feet, where the construction of the magazine proper commenced; a block of concrete was there built traversed (from inside outwards) by a circular drift 5 feet in diameter, and 6 feet 6 inches long; at this point the diameter was reduced to 3 feet 3 inches for a length of 3 feet 3 inches, whence it gradually widened out again to its original diameter. The face of the constricted portion, which was to form the seat of the plug, was strengthened by an iron framework. Towards the magazine, the circular drift in the concrete was prolonged some 10 feet in the country rock simply cemented smoothly on the inside; the plug was situated in this part of the drift. This plug was 5 feet in diameter and 5 feet long; for two-thirds of its length it consisted of circular sheets of stout pasteboard nailed together, whilst the remainder consisted of discs of soft poplar wood. The by-pass drift consisted of three sections, each 16 to 20 feet long and 5 feet 7 inches wide and high, timbered with ordinary sets. The opening furthest from the magazine, by which this by-pass drift enters the main drift, is fully open when the plug is in its normal position, but closed when it is blown against its seat. The distance from the back of the plug to its seat was 6 feet 2 inches. The magazine proper was about 25 feet from the plug; its full length was 33 feet, and its section 8 feet by 8 feet. Inside of it was arranged a charge of ½ ton of dynamite in boxes placed end to end along the floor of the magazine. When this charge was exploded a dull sound, accompanied by a slight tremor of the ground, was alone noticed; nothing was projected from the drift, and a tub standing at its mouth was not shifted. After a few seconds a small quantity of light yellowish smoke slowly escaped from the mouth of the drift. The timbering of the drift was intact, and the only part of the concrete block that was damaged was the portion that formed the seating of the plug.

In view of this successful experiment, the Commission is of opinion that with certain precautions an underground magazine of this type may be licensed for storing dynamite in amounts even exceeding ½ ton, provided that the conditions as to shapes and dimensions are strictly complied with. It is moreover recommended that it shall be forbidden to store black-powder underground, whether alone or with nitro-explosives. Detonators must not be stored in the same place as the

explosives. The explosives must be introduced and stored in closed boxes. These may only be opened and the cartridges handled in a separate chamber at least 65 feet from the magazine proper. Both these chambers must be illuminated by electric lamps or safety-lamps only. The magazine must be situated near the upcast shaft, and the drift leading to the magazine must be connected by cross drifts with the return airway, but must not open straight into this airway. Every drift shall have a blind end of about 7 feet in length, as this arrangement greatly lessens the force of an explosion. The drift that communicates with the magazine must be closed by a substantial grated door. The magazine must be ventilated by a pipe, the portion of which that passes by the seat for the plug, consisting of some waterproof material supported by a spiral of wire. Underground magazines that are not provided with a plug constructed as prescribed, shall not be licensed for more than 56 lbs. of dynamite.

Experiments have also been made with shallow underground magazines, and these tests are still in progress. So far, it would seem that favourable results have been obtained from a magazine placed at a sufficient depth below ground, the access to which is from a narrow trench, in the opposite face of which there is also a short drift to receive material projected from the drift leading to the magazine. The Commission seems to think that a magazine may be devised in some such way, a good deal safer than the existing type of above-ground magazines. H. L.

MAGAZINES FOR HIGH EXPLOSIVES.

Le Magasin Système Gathoye pour le Dépot d'Explosifs brisants. *By* JOSEPH LIBERT. *Annales des Mines de Belgique*, 1897, *vol. ii., pages* 105-109 *and* 1 *plate.*

A Belgian royal decree of October 29th, 1894, enjoins that every magazine containing dynamite, or explosives ignited with difficulty, if not situated underground, shall be visited every two hours during the day, and every hour during the night, by an armed watchman; but, while such guarding, unless continuous, is not absolutely efficacious, it involves great expense. Underground magazines may seriously compromise the safety of the workings, unless the site be absolutely unconnected with the working-places, while ministerial instructions of April 28th, 1896, forbid such magazines in the underground workings of fiery mines.

Mr. Léon Gathoye, manager of the Micheroux colliery at Soumagne, has solved the problem in another manner; and, not only has this magazine been erected at the above-named colliery, but its adoption is also under contemplation at other mines and quarries in the Liége district. It consists essentially of a domed cage, constructed of wrought-iron rods connected by flat bars, covered on the outside with 9 inches (24 centimetres) of brickwork, and lined inside with plaster, the ends of the rods, secured by flat bars, being surrounded by a cement foundation. The entrance is closed by three doors—the inner and outer of oak, and the former is also armoured on both faces with iron plates, while the middle door consists of a grating, the door-ways being well protected with iron, and each door being fitted with two locks. Six keys are required to give access to the magazine.

Article 271 of the regulations enjoins that the cases or packages of dynamite, etc., shall be contained in wooden cupboards with sides of at least $1\frac{3}{16}$ inch (3 centimetres) in thickness, closed by lock and key, and firmly fixed to the ground or walls, and this provision is more than fulfilled by Mr. Gathoye's magazine. The cupboards are of oak, lined with copper, and provided with special locks. Inasmuch as this magazine realizes a complete Faraday cage, inside which the electric potential is

absolutely *nil*, whatever be the atmospheric conditions outside, it is absolutely safe from lightning. In a magazine containing 6 cwts. (300 kilogrammes) of high explosives, the weight of iron required for the cage is about $1\frac{1}{4}$ tons (1,200 kilogrammes), which only adds about £20 (500 francs) to the cost of construction, while it fulfils every condition of security. J. W. P.

BEHAVIOUR OF EXPLOSIVES IN PRESENCE OF COAL-DUST AND FIRE-DAMP.

Versuche über Verhalten von Sprengstoffen gegenüber Kohlenstaub und Schlagwettern. *By* Carl Pusch. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1896, *vol. xliv., pages* 640-642.

Reviewing the researches on this subject published by Mr. Winkhaus,* the author points out that experiments in special galleries only partly approximate to the conditions obtaining in practical working, especially in those series where the cartridge was allowed to remain at the mouth of the cannon, and where stemming was omitted. In practice, accidents may occur in connexion with the bore-hole which will turn favourable into critical conditions, so that coal-dust and fire-damp penetrate the hole directly the shot is fired—a condition of which experiments do not afford the faintest indication. The results of these tests are therefore merely of relative merit, but capable of affording valuable indications—when combined with results obtained in practice—of the sphere within which explosives may be used with safety, and they are actually of great value as guides to the manufacturers of explosives, indicating the directions in which safety may be increased without loss of strength. C. S.

FURTHER EXPERIMENTS WITH EXPLOSIVES AT GELSENKIRCHEN.

Weitere Versuche betreffend das Verhalten von Sprengstoffen gegenüber Schlagwettern und Kohlenstaub auf der berggewerkschaftlichen Versuchsstrecke zu Braubauerschaft bei Gelsenkirchen. *By* Bergassessor Heise. *Glückauf*, 1897, *vol. xxxiii., pages* 517-523 *and* 544-549.

The experimental gallery at the No. 1 Consolidation pit was taken down and removed to another pit belonging to the same mine, where pit gas was available; its construction remained unchanged, except that it was sunk rather lower into the ground. The coal-dust used in the experiments was finely ground coal containing 28 per cent. of volatile matter, whilst in previous experiments fine coal from the screens had been used. A number of experiments were tried with explosives in suspended coal-dust without gas, suspended coal-dust with $2\frac{1}{2}$ per cent. of gas, and suspended coal-dust with $6\frac{1}{2}$ per cent. of gas, 9 per cent. being used in some special experiments with kohlen-karbonit. The composition of the explosives used and the results obtained in the experiments are recorded with much detail. It was found that considerably more ignitions were obtained in this new gallery than had been the case in the old one; the cause of this greater sensitiveness was suggested to be the greater depth of the new gallery preventing the products of the shot escaping as freely as was previously the case, or else that the finely ground coal-dust was more readily ignited than was the dust used in the earlier trials. An addition of even $2\frac{1}{2}$ per cent. of pit gas was found to notably increase the risk of explosion, and it was noticed that in the presence of even this small proportion of gas the flame of a blown-out dynamite shot was markedly lengthened.

No. 1 roburite gave anomalous and unsatisfactory results, and was found to be far less safe than formerly, though its composition was unchanged; exhaustive

* *Trans. Fed. Inst.*, vol. ix., page 250; and vol. x., pages 264 and 337.

experiments seem to indicate that the purity or otherwise of the chemicals employed in its manufacture had little to do with this irregularity, but that the mode of manufacture had a marked influence; and more especially, that intimate mixture and fine grinding produced a much safer explosive than did the opposite conditions. The author points out that to know the chemical composition and the thence calculated temperature of detonation of an ammonium-nitrate explosive is not sufficient, and that the method of manufacture must also be taken into account.

Finally, tests of some recently introduced safety explosives are also recorded.

H. L.

ELECTRIC SHOT-FIRING IN COLLIERIES.

Elektrische Zündung der Schüsse in Kohlenbergwerken. Anon. *Glückauf*, 1896, *vol. xxxii., pages* 985-988, *and* 1 *plate and figures.*

Great progress has been made in safety blasting-powders and in the safe firing of shots, electricity being applied to the latter. Electrical machines that produce a current of very low tension, so-called incandescent igniters, would seem to be best suited for coal-mining, as there is no chance of sparks being produced, but it must not be forgotten that these machines are not constant in their action and need continual repairs, whilst the detonators to be used with them are far too dear to be used in practice.

The first forms of high-tension machines or so-called spark igniters were a source of danger owing to the long high-tension sparks produced in case of a short circuit. This system had only become suitable for mining purposes since it had been found possible to construct machines of such low tension that the spark was no longer visible, and was incapable of igniting fire-damp, and since detonators had been produced sufficiently sensitive to be fired by these light electric currents.

Such machines have been proposed in France and England, but the machines used in these countries work at too high a tension, and were much too unhandy. A little machine had lately been put on the market by the Roburite factory at Witten that seemed likely to prove of permanent value in coal-mining. It consisted of a box 4·5 inches by 4·33 inches by 3·5 inches, and comprised a Siemens armature rotated by gearing between the poles of a pair of horseshoe magnets. The weight of the entire machine was about 4 lbs. The alternating current generated by this machine is of 6 volts, 0·5 ampère and 800 ohms, and is so feeble that it can scarcely be felt. The mixture with which the detonators are charged is so sensitive that a quarter turn of the handle is generally sufficient to fire it. It is only intended to fire one shot at a time. The machine is so arranged that the shot can only be fired if the contact button is pressed down whilst the handle is being turned.

These machines have been experimented on for some time at the Bonifacius mine near Krey; 890 shots were fired in coal and 250 in stone with not quite 1 per cent. of miss-fires.

The costs of the detonators per shot were:—In coal, 0·14 mark (1·6d.); in stone, 0·12 mark (1·4d.). Shots fired with safety-fuzes and Roth safety-igniters cost respectively 0·15 mark (1·8d.) and 0·13 mark (1·5d.). A small amount should be added to the former for amortisation and wear of the machines and leading wires. The machines cost 30s. The miners complained of loss of time, owing to the machine only firing shots singly, an objection that may be overcome by using larger machines. The manufacturers are now engaged on a time-igniter, to enable several shots to be fired one after the other by a simultaneous electric discharge through them.

H. L.

ELECTRICAL SHOT-FIRING, WITH REFERENCE TO ITS EMPLOYMENT IN THE PRESENCE OF FIRE-DAMP IN COLLIERIES.

Elektrische Zündung mit Rücksicht auf ihre Verwendung in Schlagwetter führenden Gruben. *By* JOHANN VON LAUER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1896, *vol. xliv.*, *pages* 599-602, 609-614, 627-631, 637-640, 650-654, *and* 669-673, *and* 1 *plate.*

Five forms of electric shot-firing may be distinguished:—(1) Frictional; (2) galvanic; (3) inductive; (4) magneto-electric; and (5) dynamo-electric.

1.—These machines consist of either discs or cylinders of glass or vulcanite, working against rubbers, the electricity generated being collected in Leyden jars or condensers. The conductors are best made of soft copper-wire, insulated by means of guttapercha, or by attachment to insulators. The igniters consists of a quantity of easily inflammable material, in which the two ends of the conductor, 0·04 to 0·20 millimetres apart, are embedded.

The advantages of the frictional electric system are, that a large number of shots (250 to 300) can be fired simultaneously with an easily portable machine, and even although the igniters are of unequal resistance. The machine, being hermetically sealed, needs no especially careful handling, and requires no repairs of any importance. The conductor may be of any kind of wire, and the igniters can easily be made very substantial.

This system has hardly any disadvantages, except, perhaps, that the current has to be generated immediately before the shot is to be fired; hence this method can be used in every kind of shot-firing.

2.—Any form of battery may be used, bichromate and Leclanché elements eing the most suitable; secondary batteries (accumulators) might also be used. The current being a feeble one, the leads must consist of good copper wires of considerable section, well insulated. The igniter consists of a fine platinum (or german silver) wire connecting two insulated wires and embedded in an easily fired mass of guncotton, meal-powder, or a mixture of antimony sulphide and potassium chlorate. Care must be taken to select igniters of about the same resistance, otherwise those with the highest resistance would explode first and destroy the connexion, unless the shots were arranged in parallel circuits. It is scarcely possible to produce a battery that shall not be unwieldy to fire more than 10 or 12 shots simultaneously. Although by this system it is possible to test the circuit by means of currents too feeble to cause ignition, and it possesses the advantage of being always ready for immediate firing, it is too cumbersome, and has too many objections to have been adopted for technical purposes.

3.—The electric current is generated by a Ruhmkorff coil, combined with a battery; the method is in general somewhat like 1, and possesses most of its advantages, but suffers from the objection of having to employ galvanic batteries.

4.—Magneto-electric machines are somewhat similar in the character of the current, etc., to frictional machines and igniters of the same type, but are much more sensitive, and are employed because the current is much feebler. These machines are not affected by atmospheric influences, and are reliable, but have too little power in proportion to their weight, and need highly sensitive igniters to fire several shots at one time.

5.—This method differs from the last-named in that permanent magnets are not employed, but electro-magnets whose magnetism is induced by the action of the armature. The currents are of low tension, and need highly sensitive igniters and very perfect conductors. The efficiency of these machines is low, and the system is considerably inferior to those using frictional and induced electric currents.

The author considers that the use of accumulators is to be preferred to every other method, using a current of low tension but considerable intensity, capable of firing two or three shots at a time, and using an igniter with platinum wire. He looks upon this as the safest method in the presence of fire-damp. H. L.

BOHEMIAN FELSPAR INDUSTRY.

Böhmens Feldspathindustrie. *By* Dr. Friedrich Katzer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1896, *vol. xliv.*, *pages* 647-650.

Established about 50 years ago, the industry of felspar-quarrying in Bohemia has had a chequered existence, owing to the irregular occurrence of the mineral in isolated masses of pegmatite—which, being quickly exhausted when the demand was brisk, necessitated constant prospecting for fresh sources—and the fluctuations in the trade.

The earliest quarries were situated in the vicinity of Horaždiowitz, and yielded felspar and quartz, but their exhaustion led to the development of the more plentiful pegmatite and granitic deposits in the gneiss district further east. At the village of Skal, near Ražitz, a very pure grey microcline, almost free from soda and lime, was worked for a long time, and the district contains numerous outcrops of pegmatite still undeveloped. Another famous quarry was that of "U Obrázku," belonging to the municipality of Pisek, which yielded a grey felspar, in addition to a large number of rare minerals prized by collectors.

This quarry has been abandoned for some time owing to the failing demand for the product. Another deposit, in the Paseka district, yielded a large quantity of felspar and quartz in 1894, but was also abandoned for the above reason. A yellow microcline is found near the Jamny road, north-east of Pisek and close to the Moldau, the pegmatite-deposit here being of considerable extent. Again, in the neighbourhood of Kloub, near Protivin, a large deposit of pegmatite, in biotite, yields an exceedingly pure felspar, entirely free from lime, and containing only a minute proportion of soda. This product is in good demand, on account of its quality and fusibility. Near Wällischbirken, a milk-blue to grey felspar, of very good quality, is won from a communal quarry, but would not meet with much sale were the price not very low—a condition rendered possible by the extraordinarily low rates of wages current in the district. C. S.

FORMATION OF HYDROGEN CARBIDES BY THE ACTION OF WATER.

Sur la Formation des Carbures d'Hydrogène gazeux et liquides par l'Action de l'Eau sur les Carbures métalliques : Classification des Carbures. *By* Henri Moissan. *Comptes Rendus de l'Académie des Sciences*, 1896, *vol. cxxii.*, *page* 1462.

The reaction which appeared to the author the most remarkable in the experiments connected with this subject is the easy production of hydrogen carbides, gaseous, liquid, or solid, by the action of cold water on certain metallic carbides; and he considered that these studies might possess interest for geologists. The disengagements of methane, more or less pure, noticed in some measures, and which have lasted for centuries, might originate in the action of water on carbide of aluminium; and a reaction of the same nature might explain the formation of liquid carbides. Starting with 9 lbs. (4 kilogrammes) of uranium carbide, the author obtained, in a single experiment, 3½ ounces (more than 100 grammes) of liquid carbides; and this mixture is chiefly composed of ethylenic carbides, with a small quantity of acety-

lenic and saturated carbides, which were generated, in the presence of a large proportion of methane and hydrogen, at the ordinary pressure and temperature, inducing the belief that, with a high temperature during the decomposition, saturated carbides similar to rock-oils might be produced.

The existence of these new metallic carbides, that can be destroyed by water, may modify the opinions hitherto entertained as to the formation of petroleum; and there exist, in all probability, rock-oils of different origins. While at Autun, the bituminous shales appear to have been produced by the decomposition of organic matter, asphalt impregnates all the fissures of the lacustrine limestone in the Limagne, this asphalt being in direct connexion with the basaltic tufa, and consequently in evident relation with the volcanic eruptions of the district. A recent bore-hole at Riom, which attained the depth of 3,936 feet (1,200 metres), brought to the surface a small quantity of petroleum; and the formation of this liquid carbide may in that case be attributed to the action of water on metallic carbides.

It is probable that, during the first geological periods of the earth's history, almost all the carbon occurred in the form of metallic carbides; and, when water intervened in the reactions, the metallic carbides yielded hydrogen carbides, and the latter carbonic acid by oxidation. An example of this reaction is, perhaps, afforded in the neighbourhood of Saint Nectaire, where the granites, which form the edge of the Tertiary basin, allow a large quantity of carbonic acid gas to escape continuously. Certain volcanic phenomena may also be attributed to the action of water on easily-decomposed metallic carbides, for geologists know full well that the last manifestation of a volcanic centre consists in very varied carburetted emanations, from asphalt and petroleum to carbon dioxide, which is the last term of all oxidation. J. W. P.

USE OF OXYGEN IN RESCUE OPERATIONS.

Verwendung des Sauerstoffes für Rettungszwecke. *By* Bergingenieur Rossner. *Berg- und Huettenmœnnische Zeitung*, 1897, *vol. lvi., pages* 193-196.

In the Elkan apparatus, an indiarubber bag is used for the transport of the oxygen from the steel storage-cylinders to the place of the accident, the gas being supplied to the sufferer by means of an indiarubber pipe, with a vulcanite-nozzle for insertion into the nostrils. When inserted in the mouth, the patient, in recovering, presses his teeth together, and might injure them on the nozzle.

At the Archduke Frederick's works, in Austrian Silesia, oxygen is kept stored in cylinders, and has already been the means of preserving workmen's lives. In March, 1896, an attendant was stupefied and burnt by blast-furnace gases, and became unconscious. Oxygen was introduced through the nose into the lungs of the sufferer, who speedily recovered consciousness. In December, 1896, four men were overcome by the fumes of an anti-corrosive paint in the inside of a boiler. A boilerminder and another workman who followed them into the boiler were also overcome, so that six men were lying unconscious in the boiler. After the lapse of several hours, the engineer emptied two cylinders containing in all about 70 cubic feet of oxygen into the boiler, whereupon the breathing of the victims was heard, and soon afterwards four of the workmen crawled out unaided. The other two workmen lay between the side of the boiler and the furnace-tube, and 70 cubic feet of oxygen was blown upon them through a hose, with the result that in a short time they, too, were able to make their way out unaided. In March, 1897, oxygen restored a family who had been poisoned by carbon monoxide.

In rescue work, a single individual carrying a supply of oxygen in any portable form may afford assistance by applying oxygen to the nostrils of injured persons. It is, however, desirable for rescuers to work, not singly, but in parties of three or four, so as to afford mutual assistance to each other. Two men can thus carry an injured workman for a short distance; in other cases, some form of litter should be adopted. Rescuers, if supplied with oxygen from a portable apparatus, by working in relays, may assist largely in the erection of stoppings, the erection or repair of ventilating-doors, brattices, etc. It would also be desirable that each workman should be provided with a reserve apparatus for use on the return journey, should he happen to penetrate too far into the workings and have an insufficient supply of oxygen left for his return. M. W. B.

HARKORT GOLD-MINES IN TRANSYLVANIA, HUNGARY.

Harkort'sche Bergwerke in Siebenbürgen. By Ad. Schünemann. *Zeitschrift für praktische Geologie*, 1896, *page* 453.

These mines have been developed on a large scale and supply 125 heads of stamps at Brad and 66 at Kristor, with a total quantity of 5,500 tons of auriferous quartz per month. This amount of quartz yields on the average 1,285 ounces of gold, the coarse gold that is first picked out and treated separately amounting to between 645 and 965 ounces per month. Concentrates and residues at the year's end give about as much also, so that the annual output would be about 25,720 ounces, worth about £80,000. In 1895-96, the production was 21,235 ounces, the cost of production being about £40,000, there being some 980 men employed. The deposits are fissure-veins traversing the eruptive rocks and tufas of the Erzgebirge of Transylvania, are more or less regular, and maintain their course both in dip and strike for considerable distances. Though originally worked by the Romans, new discoveries are nevertheless being made in these deposits.

H. L.

HISTORY OF GOLD-MINING IN THE ZILLER-THAL, AUSTRIA.

Zur Geschichte des Zeller Goldbergbaues. By Max Reichsritter von Wolfskron. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii.*, *pages* 349-353, 368-373, 383-387, 399-402, 411-414, 426-429, 441-444, *and* 455-457.

The gold-mining industry in the Salzburg district dates from the year 1427, when the Duke of Tyrol, the then Emperor of Germany, and the Archbishop of Salzburg agreed to work a mine in the district for gold and silver, but the project remained in abeyance for 200 years, when mining operations seem to have been vigorously started in the Ziller-Thal. Although the value of gold was at that time much higher than at present, other minerals were at first sought for, but in 1630 fine alluvial gold was discovered, and soon after rich gold ore. The find was of sufficient importance to bring the Archduke Leopold of Austria in person to inspect it. As the gold was on Salzburg territory, half, according to an old compact, was to belong to the Archduke, and the other half to the Archbishop of Salzburg. Taking advantage of a verbal quibble, the latter refused to admit the Archduke to a share, and caused the workings to be forcibly interrupted, and the gold-plant destroyed. War would have ensued had not the Emperor and the States of the Tyrol prevented it. In the neighbouring works, however, the mining industry was continued. The ore appears to have been dug from the mines, crushed, soaked, and washed,

of course, by hand and in primitive fashion. The percentage of gold was considered high, varying from $1\frac{1}{8}$ to $2\frac{1}{4}$ ounces per ton. About the year 1633, 73 persons were employed in quarrying, crushing and washing the ore, at an average weekly wage of about 2s. 6d. The vein of ore was rich in gold, and well repaid the cost of working, but as the mines were pushed deeper, it was found increasingly difficult to amalgamate the gold, because it contained much arsenic. Many of the workings were discontinued on that account, as the century advanced, and for 20 or 30 years they were practically abandoned. An attempt was then made to melt down the heaps of waste ore, but the proportion of arsenic was so great that it poisoned the workers. Another drawback was that too much water was used in dressing the ore.

The long contest between Salzburg and Tyrol at length ended in an agreement to work the mines in common, the miners being taken from both districts, and the managers alternately from one or the other. Gold in 1650 had a purchasing power $2\frac{1}{8}$ times more than at present, and the workmen's wages were higher relatively, considering the wretched quality of the work done. In 1681, there were 411 workmen employed, and blasting had been resorted to. This resulted in a find of extremely rich ore containing 107 ounces to the ton, and in 1686 the rich ore lately so profitably worked by the Bavarian government was opened up. By the end of the century, these rich seams had given out, and the Zeller mines were for the time partly abandoned, as with the rise in the price of commodities and provisions they no longer paid for working, although some of them were free from water. Even for that period they were not worked economically, and in 1713 a commission was appointed to examine into the expenditure. As far as possible, it was decided to do the work by contract, and to raise less barren rock to the surface. The props of the mine were strengthened, the slick more carefully washed that less gold might escape, and great efforts were made to extract gold, even by alchemy, from the waste slick and tailings. In 1746, a primitive form of the Salzburg bump-table for dressing the ore was introduced, and the initial difficulties were successfully overcome. Various empirical methods were suggested for liberating a larger quantity of gold. One quack proposed to extract it with a costly preparation of spirits of salt, possibly connected with muriatic acid which is now so much used in the process, but he did not even gain a hearing.

The method of obtaining gold was complicated. It was first crushed, washed, amalgamated and smelted; the gold slick was then conveyed to the smelting-works, washed, mixed with lead, refined, and finally separated by quartation. All these processes were not only very costly, but much gold was lost. Nor was the Salzburg table found to give satisfactory results, because the slick was so fine that the gold-dust escaped. In 1753, it was determined to set up several buddles, worked apparently by water-power, and a new kind of bore was introduced. Documents are still extant, showing the output of gold from 1660 to 1756. During this period, the average quantity of gold sent to the mint to be refined each year was about 5,000 lbs. and the output of ore about 1,000,000 tons. The proportion of gold varied from 0·047 to 0·145 ounces (1·3 grammes to 4 grammes) per ton, the Zeller ore being always high-graded. The fineness of the gold bullion during the first half of the eighteenth century was 950. The deeper the works were carried the richer was the gold-bearing quartz, but the cost of working rose in proportion. Allowing for the higher purchasing power of money, which was about double its present value 100 years ago, it cost 15s. 6d. per ton to work the ore, and this figure steadily rose, especially in the deeper mines, from which much water had to be pumped. The price may be taken at double what

it would be at present, owing to bad work and waste, particularly of blasting-powder. In some shafts, the output was only 2·8 cubic feet per shift per man. The concentrated slick was so rich, containing 26·4 ounces of gold per ton, that thefts by the workmen were common. The introduction of buddles diminished the number of men employed, but even with this mechanical help it is surprising that the works should have been carried on so long under such disadvantages. In 1786, the Borus system of amalgamation was applied to extract the gold, and towards the end of the century great efforts were made to remedy the defects in working the mines. It was proposed to dress the quartz, the slate, and the broken rock separately, and to concentrate the tailings, which had hitherto been sold as waste. The wages of the workmen were also raised, to prevent dishonesty.

At the beginning of this century, the see of the Archbishop of Salzburg was abolished, and the country passed to the Bavarian Government, who were anxious to push forward the works. New mines were opened out, the whole district being known to be rich, and private enterprise was encouraged. The quality of the ore raised in 1814 was 14 per cent. of quartz, 48 per cent. of broken rock, 38 per cent. of slate, and the proportion of gold averaged 2·4 ounces per ton of quartz. In spite, however, of all efforts to raise the standard of work, the output remained as poor as before, only one-sixth that of a neighbouring stone-quarry. Improvements were made in dressing the ore, and in 1811 a company was formed to work a new gold-vein, but although it was economically administered, and every facility given to it by the Government, it ultimately failed. Tyrol next passed under the Austrian Government, and the mines were taken over by that State. Work by contract was then introduced, and proved the final ruin of the mines. All the best workers left, no proper supervision was exercised over those who remained, new shafts were not sunk, and the old were gradually abandoned. This was the more to be regretted because the ore increased in richness the deeper the workings were carried, but the gold was unequally distributed, and when a shaft was found to be poor it was left, instead of extending the works until a richer ore was reached. The deeper the mines were dug, the more difficult it became to get rid of the water, and in 1858, at the moment of signing a contract conveying them to another company, the pumping-engine broke down. Although they opened up a rich new vein, this company suddenly stopped after 10 years, the pumps fell into decay, and the mines were drowned. The failure was chiefly due to the poverty of the company, and to the great depth reached, the cost of pumping swallowing up all the profits. B. D.

THE BERGMANNSTROST MINE AT CLAUSTHAL, GERMANY.

Über die Gangverhältnisse der Grube Bergmannstrost bei Clausthal. *By* — TINKEL. *Glückauf*, 1897, *vol. xxxiii., page 73, with 5 plates.*

This paper contains a very detailed account of the vein system worked in the Bergmannstrost mine, which is situated upon the main Burgstädter vein of the north-western Harz, and works a series of ore-shoots that form a continuation of those formerly worked in the Dorothea mine, the latter having been exhausted in the year 1886. The depth is at present 850 metres (2,800 feet). The main vein dips here from 70 to 90 degrees to the south or south-west, and in addition to it three ore-shoots ("floors") are mined, two on the hanging-wall side known as the middle shoot and the hanging shoot respectively, and one on the footwall side known as the footwall or sparry shoot; as a general rule the width of the main vein is between 8 and 12 metres (26 to 39 feet). The country-rock consists of clay slates and

greywacke, belonging to the Kulm series of the upper Harz; the general direction of the strata is about north-north-east to south-south-west, and the dip 65 to 80 degrees south-easterly. The stratification has undergone marked deviation from its normal course in the neighbourhood of the vein-fissure, having been bent round sharply till its strike is about east to west. The fissure is filled mainly with shattered fragments of the wall rocks, which have been greatly altered and mineralized by the solutions circulating in the fissure. Barren rocks or "horses" of these country-rocks, which have been but slightly shattered, and therefore carry no ore, are also to be found; the mineral constituents of the gangue are chiefly quartz, calcspar and spathic ore, the valuable minerals being argentiferous galena, zinc-blende, copper pyrites, iron pyrites and zündererz (a variety of jamesonite—Pb_4 Sb_6 S_{17}). An important observation is that the amount of silver present in the ores is diminishing with increasing depth. Thus the lead in the ores (taken at 60 per cent.) showed a diminution in the percentage of silver as follows:—In the main Burgstädter vein, it diminished from 0·0889 to 0·0609 per cent. in an increase of depth of 26 metres (85 feet). In the middle shoot, it diminished from 0·0865 to 0·0522 per cent. in an increase of depth of 125 metres (410 feet). In the Bergmannstrost hanging shoot, it diminished from 0·0732 to 0·0467 per cent. in an increased depth of 261 metres (856 feet). The ores occur either massive or irregularly distributed, rarely in bands, more often in concentric layers known as ring- or cockade-ore. In the latter case, the kernel is a fragment of clay-slate or calcspar surrounded by layers of quartz, galena, and zinc-blende; the interstices between these masses are filled with calcspar or more rarely quartz. There are evidences that the fissures have been reopened after filling, but faults are very rare. H. L.

THE GOLD-MINES OF KOCHKAR, URALS.

Les Gisements d'Or du Système de Kotchkar dans l'Oural du Sud. *By* N. Wyssotsky. *Congrès Géologique International*, 1897, *Guide des Excursions, No. VI., pages* 1-6, *with map.*

This district lies on the eastern slope of the Southern Urals, about 50 miles south-west of Miass. It comprises something like 360 to 400 gold-deposits, all situated along the upper course of five small streams, the Kochkara, Chornaia, Osseika, Kamenka and Sanarka. Placers have been worked here from 1844 onwards, and as these became exhausted the gold-reefs discovered between 1863 and 1867 have been more actively exploited.

In the middle of a broad belt of granite, which runs parallel to the meridian, the rocks have undergone much dislocation and fissuring in a transverse direction, and the granite has been partly broken up and metamorphosed. The auriferous country-rock is berezite, a granite wherein the felspar is almost wholly replaced by quartz and muscovite: the gold-quartz veins (50 or more in number) appear to have arisen from the kaolinization of the granite, and form a network, the general strike of which is east-and-west to south-east and south-west.

The veins vary in thickness from 2 inches to 6½ feet or more; they pitch almost vertically, and consist of grey or greenish opaque quartz with inclusions and venules of mispickel, pyrites, stibine and galena. They are richest near the surface, and it is noticed that lower down the proportion of gold increases concurrently with that of mispickel. The average gold content is 100 to 200 grains per ton, and the gold contains about 30 per cent. of silver.

In most of the workings, so far, only the decomposed rock has been touched: it is easily broken up and treated by the amalgamation process. The decomposed rock sometimes extends down to a depth of about 180 feet; from this depth down to 450 feet or more the undecomposed rock is worked, the auriferous material

being separated from the accompanying ores by the *stossherd*, or frue vanner, and then chlorinated or cyanized.

The author gives a short description of the Mitrofaniev, Gavriilo-Arkhangelsk, Woskressenski, and other deep-level mines, and then refers to the deposits of secondary origin. These belong to the type of placers *in situ*, or placers which are very little removed from their original point of formation, and they are mostly in intimate relationship with the quartz-reefs. In the largest placer of all, the richest portions run in a belt parallel to the outcrop of the reefs. The ordinary structure of these placers is as follows (in descending order) :—Variegated stiff clay (barren), 13 to 40 feet ; coarse sand with quartz and granite-pebbles, and gold in its lower portion, 1½ to 5 feet. The gold content varies from 20 to 160 grains per ton : this coarse sand is underlain by decomposed granite, containing much the same amount of gold. Some of the placers are recent, others date from Pleistocene times.

The paper is preceded by a bibliographical list. L. L. B.

PHENOMENA CONNECTED WITH THE ORE DEPOSITS OF THE LA CAROLINA AND SANTA ELENA MINING DISTRICT, SPAIN.

Fragen und Anregungen die sich an das Auftreten der Erze im Gangrevier La Carolina-Santa Elena (Spanien) knüpfen. *By* A. O. Wittelsbach. *Zeitschrift für praktische Geologie*, 1897, *page* 5, *and illustration.*

The villages of La Carolina and Santa Elena are situated on the southern spurs of the Sierra Morena, respectively 18 and 25 kilometres (11 and 15 miles) north of the well known lead-producing district of Linares. The district consists of Palæozoic slate, with alternations of eruptive granite ; both these rocks are traversed by two series of fissures, one a productive series, with a strike varying from north-west to west-north-west, and the other a series of cross fissures at right angles to the former, older than the latter, filled chiefly with quartz and country rock, and never worth working. The veins pass from granite to slate alternately without their course in strike or dip being in the least affected, although the nature of their filling is markedly so.

The next and most recent formation in the district is Triassic, patches of which overlie the others, but are nowhere traversed by the vein-fissures.

The principal ore is galena, often converted into cerussite in the upper levels ; blende is rare, copper and iron pyrites more plentiful, the non-metallic minerals being chiefly quartz and barytes. The veins are chiefly filled with comminuted wall-rock, partly metamorphosed. In the granite, which is rich in felspar, the veins are filled with kaolin-like masses, known as *gredas*. The important point to note is that certain of the fissure-veins, *e.g.*, the Esperanza and San Gabriel veins carry lead ores only in the granite, and become absolutely barren in the slates which they also traverse. In the granite, near to the boundaries of that rock with the slates, the veins suddenly become much richer than in the average of their course. On the other hand, the El Castillo vein, dipping southward like the others, and having a strike differing only 15 degrees from the former, together with some minor veins, shows exactly the opposite phenomena, that is to say, it is lead-bearing only in the slates, and barren in the granite. None of these alterations in richness are accompanied by any change of direction.

The silver content of the veins is somewhat variable, though a good deal higher than in the Linares district ; the country-rock seems not to affect the richness of the lead in silver, although the latter appears here as in some other localities to become poorer in depth.

The author is unable to offer any explanation of the above phenomena.

H. L.

NATURE AND ORIGIN OF THE SEJA GOLD-DEPOSITS, EASTERN SIBERIA.

Die geologischen Entstehungsverhältnisse einiger Goldlager. *By* P. Javorovsky. *Zapiski imperatorskavo S. Peterburgskavo Mineralogicheskavo Obshchestva*, 1895, *vol. xxxiii., pages* 307-351, *with figures in the text.*

The extreme importance of the part played by the tectonic character of the auriferous parent-rock in determining the formation of gold-deposits, their richness in ore, etc., was impressed upon the author in the course of his examination of the Seja gold-deposits, which rank among the richest in Eastern Siberia. The best portion of the Seja group comprises the localities situated on the right-bank affluents of the Ilikan, and of this portion of the area the author supplies a sketch-map showing that the rocks are gneisses and granites.

The first-named are traversed by numerous bedded quartz-reefs, whose breadth varies between a few inches and 13 feet or more. Most of the reefs are auriferous, but very poorly mineralized, averaging 2½ to 5 grammes per metric ton (or 0·09 to 0·18 ounces per British ton).

The granites, of a light-grey colour, are peculiar therein, that they are chiefly made up of nearly spherical quartz-grains, whereas the felspar appears to act, so to say, as the cementing-material. Consequently the slightest weathering of the felspar causes the rock to crumble away, and the quartz-grains, the biggest of which are of the size of a pea, are easily swept away by streams having a very low gradient of fall—a circumstance which has no small influence on the accumulation of the auriferous deposits.

In the district under consideration, the granite generally occupies the middle and lower portions of the river-basins, while gneiss crops out in the upper courses of the rivers.

The author then proceeds to describe the Chálon valley deposits which are worked by a company in whose service he was engaged in 1889 to 1890. The Chálon is a small, quietly flowing stream, about 5 miles in length, very different in character from the torrential water-courses which predominate in that area. The valley is fairly broad, sloping gently to the right bank, while here and there the left bank is a steep scarp. The physiography recalls that of many of the auriferous districts in the Southern Urals.

The auriferous deposits overlie the granite, from which they are separated by a bed of granite-rubble. They are gravels and pebble-beds, loosely held together by an argillaceous cement, and do not generally exceed 13 feet in thickness. In the main they are made up of *débris* of the gneisses, hornblende-rock, and quartz, granite-*débris* playing only a secondary part. In the upper layers, however, the latter crowd out the gneiss-pebbles, and at the same time the argillaceous cementing material increases in amount. While the gneiss-*débris* are well rounded and smooth, the granite-fragments are angular and rough-surfaced. The gravel and sand consist almost wholly of quartz-grains, which, by their form and the traces of adhering felspar, give evidence of their derivation from the granites.

The deposit is richest in gold at the bottom, and becomes poorer upwards, coincident with the increase in number of the granite-fragments as compared with the gneiss-pebbles. The uppermost layers have not been worked hitherto, as in practice only such layers are regarded as auriferous which yield at least 0·25 gramme per metric ton (or 0·009 ounce per British ton), and these are struck here at a depth of about 5 feet from the surface. It is known, however, that the gold is disseminated right through the deposits, from top to bottom.

As regards the horizontal distribution of the gold, that appears to be fairly regular within each area, but the yield from each washing depends upon its particular position along the stream. Thus, the sand from the middle course yields on an average 0·46 ounce per ton, that from the lower course rather less than 0·08 ounce per ton, and that from the upper course 0·21 ounce per ton. Taking a cross-section of a deposit, it is found that the central portion is often astoundingly rich in gold, and the author quotes such miraculous figures as 22·4 ounces, 89·6 ounces, and even 627·2 ounces per ton, but doubtless these are very exceptional cases. Despite the small dimensions of the gold particles, the very gentlest spraying with water shows the sandy working-face all bespangled with glittering flakes; and these being too small to pick out with the fingers, dishonest workmen have found it much simpler to steal the sand just as it is. A gloveful will yield as much as 1 or even 1½ ounces of gold. The average production of the entire deposit is small in comparison with the figures just quoted, because it includes the washings from all the portions worked, poor as well as rich. From the central portion outward, the gold content diminishes gradually in every direction, and this shows that here the auriferous concentration at a particular point cannot be referred to the usually assigned cause, namely, that where the gold lies thickest was the point of greatest activity of the current which formed the deposit.

The author draws attention to a peculiarity which may remind English readers of the Banket beds of the Witwatersrand, namely, that the gold either is most thickly accumulated immediately underneath the pebbles, or is fast cemented to them by an argillaceous substance which fills up all depressions in the under-surface of the pebbles. If a sample of the auriferous sand-and-gravel be taken, and the pebbles with their adhering cement be picked out, it can be proved that something like 50 per cent. of the total gold content is thereby eliminated. The origin of this cementing-material appears to be exemplified in an auriferous thin layer of silt or mud which is seen to underlie great masses of granite and other boulders at many spots along the banks of the Ilikan river (of which the Chálon is a tributary).

Along the Sanar, the Khorogachi, and the Chegdali rivers are gold-deposits similar to, but poorer than, those of the Chálon Valley. These water-courses run in steep ravines cut through the granite. In the deposits on the Horatius brook, on the other hand, the argillaceous cementing-material of the gneiss-pebbles plays an even more important part than in the Chálon gravels. The uppermost layers, too, are often rich in gold, and the metal occurs in a state of less fine division, nuggets being found up to 3 ounces and more in weight. The average production is 0·2 ounce per ton of material washed. Lastly, in the Chalta Valley, the gold is more widely disseminated than elsewhere in this area.

The author then proceeds to discuss the question of the parent rock whence the gold of the Seja region was primarily derived. Everything points to the gneiss. To confirm this conclusion, the author made a careful survey of the ground. It was noticeable that everywhere over the surface of the granite gneiss-boulders of various dimensions lay scattered around, and at last he discovered a spot where highly weathered hornblende-gneiss was exposed *in situ* overlying the granite, and filling up the bottom of a small synclinal. On the north, this outcrop is fringed by a zone of gneiss-rubble, and samples of this latter yielded on assay a considerable amount of gold. Plainly, the granite was at one time completely covered over by the gneiss. That no gold is present in the granite itself was proved again and again by crushing and assaying samples of the rock, and this at a spot where the miners at first sight appeared to have struck a gold quartz-vein in the hitherto barren granite, while a careful examination showed that the vein was really enclosed in gneiss, faulted in among highly-disturbed overthrust granite.

The tectonic relationships of the area may be summarized as follows:—A highly compressed anticlinal fold, with a granite core and limbs of gneiss, was, at the moment of dislocation, fractured along the bedding-planes, and the fissures were subsequently infiltrated with auriferous quartz. At a later period, secondary folding and intense faulting took place, with the result that the gneiss and the associated quartz-reefs were let down to a considerable depth.

Various points in connexion with the distribution and habit of the gold in the placers, such as the origin of its flakiness and shagreened surface, its association with the pebbles, and the relation between the progress of valley-sculpturing and the lessening in size and quantity of the auriferous particles floated down, are then considered in great detail; and the author attaches much importance to the conclusion that rich gold-placers are by no means necessarily derived from a highly auriferous parent-rock. Given the necessary geological conditions, rich deposits may originate from the erosion of a rock comparatively poor in gold.

The deposits herein described appear to the author to demonstrate the need of expanding Prof. Von Cotta's classification of placer-deposits, which lays too much stress on the travel of the gold and its associates in one particular direction. In their journey down the valley from their place of primary origin the auriferous particles moved in three directions: (1) vertically, (2) horizontally, across the valley, and (3) horizontally, along the valley. He proposes the following extended classification:—

I. Alluvial gold-deposits:—(1) *Stricto sensu;* (2) Detrital deposits.
II. Sunken gold-deposits formed *in loco*:—(1) On the parent-rock or matrix; (2) On a bed of foreign rock.
III. Deposits formed from drifted material:—(1) In river-valleys; (2) In the sea (?).
IV. Mixed gold-deposits.

The author defines as *alluvial*, properly so-called, those deposits wherein the materials derived from the erosion of the parent-rock have received no further enrichment from the water flowing to them, and as *detrital* those which have been so enriched. *Sunken* gold-deposits are those where the gold and its associates have by reason of gravity reached the bottom of a stream-bed too fast to travel any appreciable distance. On the other hand, those formed from *drifted* material are accumulated at some distance from their point of origin; and the term *mixed* gold-deposits applies especially to those along mountain-rivers and streamlets which partake of the characters both of the *sunken* and *drifted* deposits.

L. L. B.

GOLD-FIELDS OF TRANSVAAL AND CHARTERLAND, SOUTH AFRICA.

(1) *Études sur les Champs aurifères de l'Afrique du Sud.* *By* Albert Bordeaux. *Revue Universelle des Mines*, 1897, *vol. xxxii., pages* 1-67, *with* 2 *plates.*

The geological formation of the Transvaal is simple, consisting of strata of schists, quartzites, grits and conglomerates overlain by a dolomitic series with siliceous sands and argillaceous schists, interbedded with lenticular masses of coal. All these strata lie upon granite which crops out over large areas of country especially on the north, the south-east, and the central plateau of Charterland. The general direction of all the stratification takes the form of almost concentric arcs, whose centre lies in Basutoland.

Whilst the general arrangement of these strata is fairly regular, local disturbances are of but little importance, and consist in intrusions of various forms of greenstone that have penetrated even the granite.

The most important fold appears to have upheaved, subsequently to a portion of its deposits, the whole system on the north and south, at the Zoutpansberg and the Witwatersrand, and to have brought about intense erosive action by exposing to the air and water enormous masses of quartzose and felspathic rocks. This fold appears to explain the fact that none but quartz-pebbles are found in the conglomerates, the sandstones, and the quartzites, the disintegrated granites having only left behind their quartz elements. Moreover, the granites also appear on the north of the Transvaal, in the whole central region of the Charterland, forming what may be called the backbone of South Africa, and showing evidence of powerful erosive action. The altitude of the Charterland granites varies from 4,500 to 5,500 feet, being thus equal to that of the Transvaal sedimentary deposits; but the altitude of a portion of these latter is due to an upheaval the amplitude of which is still difficult to determine, while it may be admitted that the sedimentary deposits began in the less elevated regions of the central plateau. As one descends this granite-plateau, either on the east or on the west, the effects of erosion are more and more manifest; and the valleys are formed, first in the sediments, and then in the granite itself which is laid bare, while the face of the country assumes the characteristic aspect of South Africa, being studded with hills formed of granite-blocks.

The basin of the Witwatersrand appears to form a huge synclinal, the axis of which runs about east-north-east to west-south-west. It rests upon granite, and consists of the following formations:—(1) Schists, known as Letaba schists. (2) Grits, quartzites and schists, without conglomerates; one of the beds of schists is characteristic and is called the Hospital Hill schist. (3) Grits, quartzites and schists, with auriferous conglomerates, coeval with the grits and conglomerates of Table Mountain. (4) Dolomitic limestone series, unconformable to the foregoing. (5) The series of schists, grits and quartzites of Magaliesberg and Gatsrand, enclosing lenticular deposits of coal, some of great thickness.

The author proceeds to describe the system of reefs in detail, and draws the following general conclusions:—(1) The richness in gold of the reefs is independent of the amount of pyrites they contain. (2) The average yield does not diminish in depth. (3) The yield increases simultaneously in the different reefs of the Main Reef series in the various zones of the Rand. (4) There is no gold in the conglomerates without cementing-material, called Bastard Reefs; the pebbles in them appear to be barren. (5) Pebbles of quartz carrying gold, and some of them rich, have, however, been found in several reefs. (6) Crystallized gold has been found in several mines, due to a redeposition of the gold in the fissures of pebbles or about their surfaces. (7) Rich shoots exist, sometimes nearly vertical, at others more nearly horizontal, cut off by faults or dykes. (8) The line of the reefs, even in the central portion of the Rand, is far from being well defined or continuous. (9) Rich deposits should rather be looked upon as zones in the entire series of grits, quartzites and conglomerates. (10) The flatter a reef lies the poorer it is; this effect is not, however, produced in depth. This seems to be a proof that the steep pitch of the reefs was produced after their formation, but that this formation itself took place at various angles, the steeper of which were the more favourable to the existence of gold. (11) A reef often passes into the surrounding quartzite, which then becomes auriferous. (12) Veins of secondary quartz, at times some inches in thickness, are abundant in the banket itself. (13) A selvage of clay often occurs along the walls of the reefs, due perhaps to the attrition of the pebbles of the upper conglomerate. (14) Zones of local impoverishment appear in depth analogous to the characters of the outcrops. (15) Near certain faults the reefs are seen to bend,

and apparently penetrate into the faults. These faults still cause an infiltration of water, and may have done so from the first. (16) The ore is locally stratified, especially in the hollows of the curves of the Black Reef. (17) Horizontal throw of the reefs is sometimes combined with vertical throw. (18) There are numerous small slips in the reefs, very often parallel in the undisturbed portions, at times concentric in the folded or disturbed portions. (19) Pyrites sometimes occurs in disseminations separated by empty spaces, more often in compact masses, in which gold can be seen under the magnifying glass. (20) Pyrites is the only abundant mineral present, though others occur exceptionally. (21) The cementing-material contains chlorite, cyanite, steatite, serpentine and mica, all appearing to be derived from the remains of micaceous granite. (22) In some reefs, the quartz-pebbles have a curiously flattened shape. (23) The dykes consist of a hornblendic micaceous diorite, various diabases, olivine-norite, or basalt; a few zeolites have been found in places. (24) Some of the eruptive rocks are auriferous. (25) It seems probable that the gold is of secondary origin, brought about after the deposition of the conglomerates by the intrusions of eruptive rocks; these have made their way along planes of fissure or of faulting. (26) The gold is generally crystallized in cubes or in flat scales. (27) The richest zones seem to be those where the greatest amount of dislocation has taken place.

Neither at Klerksdorp nor at Heidelberg is there any series of reefs that may be compared with those of the Witwatersrand, either in extent or value; and there are only exceptions which have yielded, or which appear as if they ought to yield results worthy of a working, and even then over sufficiently restricted areas, as is the case with Eastleigh at Klerksdorp, with Nigel, and perhaps with Heidelberg-Roodeport and with Molyneux at Heidelberg. H. L. AND J. W. P.

(2) *Etudes sur les Champs aurifères de Lydenburg, de Kaap et du Charterland, Afrique du Sud. By* A. BORDEAUX. *Annales des Mines*, 1897, *vol. xi., pages* 273-349, *and* 3 *sketch-maps.*

The author has studied the above-named three gold-fields and gives the result of his observations.

De Kaap and Komati.—These two river-valleys are approximately parallel, both entering the Crocodile river. The geological formation is among the most ancient of South Africa. The base is formed of coarse-grained granite, syenite and pegmatite, whilst the hills that separate the two valleys consist of schists, quartzites, conglomerates and sometimes of fissile clay-slates, with a general east-and-west strike, subject to numerous dislocations, so that the strike is even at times north-and-south. These bedded rocks attain no great importance except in the Makongwa mountains, at the angle of which stands the Sheba Hill, and where their thickness exceeds 10 miles. This belt of stratified rock is continued eastwards in a narrow strip on Moodie's, another narrow strip running from North Kaap to Barrett's Berlin and Cootjestroom. All these rocks are traversed by dioritic dykes. Gold exists indifferently in all the stratified rocks, but this auriferous impregnation is confined to narrow belts from 100 to 500 feet in width, though often of great length; each such belt may contain one or several auriferous lines, one of which only is, as a rule, workable. True fissure-veins do not seem to occur; there has, rather, been an impregnation of gold through the planes of fissure, as on the Rand; veins and pockets of quartz, often auriferous, have thus been produced. The quartz is often black, which colour may be attributed to the presence of bituminous particles which possess the property of precipitating gold.

The Barberton gold reefs form five groups, namely, Three Sisters, Sheba Hill,

North Kaap, Barberton and Moodie's. The Sheba mine on Sheba Hill is the oldest and most celebrated mine in the Transvaal. The formation here strikes east-and-west, and dips 50 to 62 degrees to the south. The succession of strata from north to south is as follows:—(1) Blue bar, consisting chiefly of talcose schist carrying pyrites and free gold; (2) reef, consisting of quartzite with bunches and veinlets of black quartz veined with white, the black carrying the gold and the white being quite barren; (3) very dark quartzites; (4) schistose slates; (5) conglomerate, a true banket, carrying a few pennyweights of gold to the ton; and (6) schistose slates of country-rock. The Sheba reef thus consists of ramifications of black quartz in a bed of quartzite; and, generally speaking, it seems to get narrower on going downwards. The auriferous portions form shoots; the main shoot worked in the Sheba is 40 to 70 feet thick and 260 to 400 feet long. It dips with the quartzite to the south, and also dips 70 to 75 degrees to the west. The mineralization is due to the numerous outbursts of diorite. The other gold-bearing shoots on this line are much smaller and poorer.

In the North Kaap, there are reefs of arsenical pyrites carrying gold at the Consort, and various reefs of little importance, *e.g.*, at the Albion, North Sheba, etc. At the Kantoor, a bed of conglomerate has yielded about 4 dwts. of gold to the ton; at Barrett's Berlin, deposits of gravel carrying coarse nuggets, showing traces of crystallization, are worked.

About Barberton, there are numerous reefs of black quartz like that of the Sheba, but the deposits are not permanent, and of little importance. At Moodie's, the reefs are of very white quartz in green chloritic schists; there are two gold-belts, one on the north containing the Pioneer reefs, and another on the south traversed by the Ivy reefs.

In Steynsdorp and Swaziland, the formation is like that of De Kaap; the reefs are of white quartz in schist, but are even less permanent or continuous than on Moodie's.

Lydenburg and Pilgrim's Rest.—Much alluvial has been worked here, notably in the Blyde valley. The district consists of a series of grits, sandstones, schists, conglomerates and quartzites, intercalated with dolomite, the latter formation carrying the gold in veins of "rotten" saccharoidal quartz. The most important is the Theta reef at Pilgrim's Rest; Mac-Mac, Spitzkop, and Watervaal are the other gold-fields of the district, at all of which alluvials have been worked; veins are also known, but three-fourths of the gold comes from the reefs of Pilgrim's Rest.

Rhodesia or Charterland.—The general formation is granite and metamorphic gneiss, traversed by belts of schist running generally north-east and south-west, and traversed by numerous dykes of eruptive rock. The gold-bearing zones are generally confined to the schists which are chloritic or micaceous, and traversed by veins of quartz. A little gold is also found in diorite, and even in certain granites. The reefs may be divided into four classes:—1. Contact-veins between metamorphic schists and diorite or granite. 2. Fissure-veins in granite, usually superficial. 3. Fissure-veins in the schists generally parallel to the foliation, more rarely crossing it. 4. Impregnation of diorites or of kaolin resulting from the decomposition of diorite.

In Manicaland, a few reefs are known, *e.g.*, Guy Fawkes, Lion, Rezende, Penhalonga, Champion, Grand Duke, etc. On many of these, ancient workings have been found, but little work has yet been done, and some of the reefs seem to pinch or cut out in depth.

In Mashonaland, the Salisbury and Enterprise district is the most advanced, there being a five-stamp battery working on the Salisbury reef; many of the reefs seem to be pyritic.

In the Mazoe district, there are a large number of reefs, but there are no developments worth mentioning, though there are numerous ancient workings.

The principal mine of the Le Mogundis district is the Ayrshire, opened on a dyke of auriferous diorite, assays of which show, however, more silver than gold; fine specimens of diorite, enclosing lumps of free gold, have been found. There are a number of old workings and of quartz-reefs in this district, such, for instance, as the Mandora, which is generally poor, though with rich patches.

In the Hartley Hills district, there is only one five-stamp battery at work; several reefs are known, but have been but little worked; in some places, surface-crushings have given high returns.

In the Victoria district, there are many reefs, but these do not seem to have carried as well in depth as their outcrops promised.

In Matabeleland, the reefs and formations are similar to those of Mashonaland; numerous concessions have been taken up, but little work has been done so far.

The author's general conclusion is that though the generality of the reefs are of little value on account of the geological conditions of Charterland, it is yet probable that in some points, where old workings are extensive, but have either been imperfectly explored or not explored at all, reefs of sufficient size and value to be worth working on a serious scale may yet be met with. Transport is at present the great difficulty, but in the future a large portion of Charterland will be valuable for agricultural and pastoral purposes. H. L.

(3) *Ueber die Goldvorkommen im Lydenburger District.* *By* J. Kuntz. *Zeitschrift für praktische Geologie*, 1896, *page* 433, *and* 10 *illustrations.*

Lydenburg.—The Lydenburg gold-field was the first known of the gold-fields of the Transvaal, though its development has been less rapid than that of the Witwatersrand. It lies in the Drakensberg range, the geological sequence of formations being the following from below upwards: —

Granitic rocks form the basement-rocks, and occupy the low country, above which rises quite precipitously the Lydenburg Sandstone, or lower sandstone, containing occasional beds of conglomerates (not auriferous) and slates. Above this lies the dolomite known as Olifantsklip to the Boers; it is a dark bluish-grey crystalline rock, some 500 feet to 800 feet thick, containing numerous bands of an amorphous or cryptocrystalline quartz generally called hornstone. Thin beds of slate also occur, especially near the top and bottom of the formation, as also do occasional sheets of greenstone, which is generally decomposed into a clayey mass.

Above the dolomite lies the upper sandstone formation, consisting of a series of alternate beds of fine-grained sandstones and sandy slates, traversed by diorite dykes which occasionally form sheets intercalated in the stratification.

All the workable occurrences of gold in the district have been confined to the dolomites, which crop out over a width of some 2 miles. These comprise the deposits known as the Glynn reef, Frankfort reef, Clewer or Morgenzon reef, Beta reef, Theta reef, Chi-Psi-Nu reef and Jubilee reef.

These deposits all consist of crystalline, cellular, porous saccharoidal quartz, yellowish to brownish where rich in gold, hard and white where poor. The ore is often intermixed with slate and with a manganiferous earthy substance (mud); there are at times partings in the ore consisting of slate, dolomite, hornstone, earthy mud, or more rarely decomposed greenstone. The gold is very finely disseminated, very rarely visible to the naked eye, and the richness of the deposits varies from traces to 40 ounces to the ton.

The deposits are very variable in thickness, sometimes wedging out entirely, sometimes over 10 feet thick. The general lie of the deposits is almost horizontal with a slight dip to the westward, but continuous minor undulations occur forming alternate basins and saddles, whilst near their outcrops on the hill-flank the strata are bent downwards sharply. The roof is generally extremely bad and requires much timbering. The various reefs occur at different horizons in the dolomite, the Glynn reef being only 100 feet above the base of the bed, whilst the Jubilee reef has for its roof a hornstone-bed about 20 feet thick that is immediately overlain by slates. The Theta reef, too, lies under a bed of hornstone which is directly underneath the lowest beds of the upper sandstone, whilst there are above the Beta reef some 65 to 80 feet of dolomite containing no other deposits; it is difficult to say whether these two last-named, which are separated from each other by a valley, really form one deposit or not. It has been observed that the Beta reef is richest in the neighbourhood of the greenstone-dykes that traverse it; and thin slaty partings in this reef are also generally very rich in gold.

The general method of mining is by bord and pillar, the latter being left some 50 feet square, but is irregular, corresponding to the irregularities of the deposits. The ores are treated by crushing in stamp mills and cyanidation, water-power being abundant.

There are various opinions as to the mode of formation of the deposits; they are sometimes looked upon as bedded veins, but the appearances do not seem to favour this view; neither can they be original members of the formation. They do not seem always to lie strictly parallel to the stratification, both roof and floor being very irregular. It is probable that flat hollow spaces have been formed by the solution of the dolomite, and that these spaces have been subsequently filled with other materials, mainly auriferous and ferriferous quartz, by some change in the chemical character of the solutions. This assumption renders it probable that the deposits will not continue in depth, *i.e.*, below the permanent water-level.

Another mode of occurrence of gold quartz in the dolomite is that of the so-called "diggers' leaders;" these consist of a great number of stringers of quartz that traverse the dolomite in places, and especially the lower strata; these stringers vary from the thickness of a sheet of paper to about 6 inches, and are on the average 50 feet apart, and traverse beds of slate, sandstone, dolomite, and decomposed greenstone; they are barren in the last-named, poor in the dolomite, carry 1 to 3 ounces to the ton in the sandstone, and 10 to 30 or even up to 50 ounces in the slate. They are only rich in the neighbourhood (say 200 feet on either side) of an older greenstone dyke and are cut off or thrown by a more recent one.

In the upper sandstone-formations, reefs have been worked similar to those already described, but have never given satisfactory results. H. L.

(4) *Étude Technique sur les Mines d'Or du Witwatersrand.* *By* Leon Demaret. *Annales des Mines de Belgique*, 1897, *vol. ii., pages* 2-88, *with plans, sections, and drawings.*

Witwatersrand.—Between Pretoria and Johannesburg, there emerges a large granitic mass of elliptical form, the axis of which, bearing east and west, forms an anticlinal. On the north of Pretoria, the strata resting on the mass of granite dip towards the north; and on the south, at Johannesburg, they dip towards the south, then form a synclinal, and again rise, to crop out at the Vaal river with the dip to the north. This synclinal contains the seams of conglomerate that are now worked, which consist of quartzose elements neither pyritiferous nor auriferous, connected by a siliceous cement both pyritiferous and auriferous. The axis of the synclinal bears north-east and south-west; and on following the granite-mass

towards the south the following rocks are found:—(1) Granite and gneiss; (2) Quartzites and white sandstones; (3) Schists, fine ferruginous sandstones and quartzites; (4) Quartzites and auriferous conglomerates; (5) Dolomite; (6) Gatsrand and Magaliesberg quartzites, and (7) Karoo deposits, which contain seams of coal varying from 2 feet to 21 feet in thickness.

The auriferous conglomerates comprise the following "reefs" or seams (in an upward direction) *e.g.*, from north to south starting from Pretoria:—(*a*) Rietfontein reef; (*b*) Main reef, including the North reef, Main reef proper, Main reef leader, and South reef; (*c*) Bird or Monarch reef; (*d*) Kimberley or Battery reef; (*e*) Elsburg reef; and (*f*) Black reef. These seams were formed at the bottom of a sea into which the continental rivers hurried along the pebbles and sands washed from the mountains, this being a littoral formation deposited in strata originally horizontal; but the movements of the earth's crust and granite-eruptions have subsequently folded them into a synclinal, the axis of which is approximately east and west, while to the north of it is an anticlinal. The opinion of some authorities that the quartz, which alone constitutes the pebbles, does not necessarily proceed from veins containing quartz alone, but may be due to quartziferous rocks of which the other elements than the quartz have been triturated and carried away, is not endorsed by the author, who considers it more logical to suppose that these pebbles were simply formed by the destruction of quartz-veins.

The various theories for explaining the presence of gold in the conglomeratic strata are summed up in the following terms, to each of which are added the arguments for and against:—(*a*) The conglomerate-seams are only solidified placers, being due to the erosion of pyritiferous and auriferous quartz-veins. (*b*) The gold and pyrites dissolved in sea-water have been precipitated by decomposed organic matter at the same time as the strata of quartz-pebbles were formed. (*c*) The pyritous and auriferous impregnation was subsequent to the deposit of the conglomerate-seams. (*d*) The conglomerate-seams have a fluvial origin.

The first mines opened were naturally those on the outcrop, and were worked either by slants into the seam or by small vertical shafts. When the continuance of the deposit in depth was proved, fresh concessions were taken up to the south of the former; and access was only obtained to these deep levels by vertical shafts.

The concessions are included in three zones roughly parallel and bearing east and west, viz., the northern zone of 2,000 feet mean width, comprising 70 outcrop mines, in which gold has been proved by actual working, and of which one-half now produce gold, while the other half will soon do so; the second zone, varying from 1,000 feet to 4,000 feet in width, now comprising 12 deep-level mines, six of which have not only proved the deposit worked in the outcrop mines, but are carrying out preparatory workings, or have actually begun to work; and the southern or third zone, that of the extreme deep levels, the width of which cannot yet be assigned, the deposit being at present only known by borings.

The author then describes the claims with the estimated quantity of ore per claim; gives the depths of the shafts in the deep-level mines; deals with the persistence of ore-seams in depth, and also that of the ore's richness in depth, with the limit depth of working, and, by way of example, the expenses of winning the Geldenhuis Deep mine.

He sets forth the following conclusions:—The persistence of the ore in depth, while preserving the mean richness in the basin, is ensured by the stratified nature of the deposit, by the deep workings of the outcrop mines and by the shafts and bore-holes in the deep levels; but, inasmuch as the workings in the outcrops have shown that the deposit comprises rich, moderately rich, and poor regions, one

must expect to find these three classes of regions in the deep levels. Moreover, as the dimensions of these various regions are unknown, it must only be considered probable, and not certain, that a deep-level mine is rich because situated to the south of a rich outcrop mine, or that deep-level mines are poor because a shaft or bore-hole, sunk at an isolated point, may have passed through poor ore.

J. W. P.

(5) *Ueber den Einfluss der Eruptivgesteine auf die Erzführung der Witwatersrand-Conglomerate und der im dolomitischen Kalkgebirge von Lydenburg auftretenden Quartzflötze, nebst einer kurzen Schilderung der Grubenbezirke von Pilgrim's Rest und De Kaap, Transvaal. By* Paul R. Krause. *Zeitschrift für praktische Geologie*, 1897, *pages* 12-25, *and* 1 *plate and* 9 *figures.*

Witwatersrand.—The character of the Witwatersrand formation is being studied by means of bore-holes and deep-level mines, whilst the mode of origin of the gold in the conglomerates has been comparatively neglected; various theories have, however, been put forward, according to some of which the gold existed in the constituents of the conglomerates even before the latter were formed, whilst according to others it was deposited during and according to some others, after their formation.

With regard to the first view, which was the original one, it has been shown repeatedly that, with the exception of one or two doubtful examples, the pebbles contain no gold, this metal being concentrated in the cementing-material. Seams of rolled pyrites or pyritic sand are said to have been noticed in places, but this fact, if established, would only prove that the cement included minute quantities of previously crystalline mineral matter. The gold, however, is very finely divided, and is in intimate mechanical but not chemical connexion with crystallized pyrites. This view, however, that the Witwatersrand conglomerates have been formed by the disintegration of gold-bearing quartz-veins has to-day been pretty well given up, even by its former advocates.

The second theory is to the effect that, simultaneously with the deposition of the sands and gravels, a continual process of precipitation from sea water was taking place. This view suffers, however, from a mass of internal contradictions; thus, the formation of beds of conglomerate extending for hundreds of miles could only have been produced under the action of violent currents, which would surely prevent a quiet and continuous precipitation from solution. Again, how can the fact be explained that such precipitation only enriched the conglomerate-beds lying at considerable vertical distances apart and not the strata of sandstone that alternate with them.

This theory seems, therefore, not to be tenable, hence we are brought to the third, namely, that mineralization was subsequently produced by metalliferous solutions ascending from the interior of the earth. The ascent of these enriching vapours and thermal waters was probably connected with outbursts of eruptive rocks. These eruptions must have been almost simultaneous with the elevation of the granite, and the molten rocks apparently found their way originally through the fault-fissures, and afterwards either broke through the strata or else made their way between the latter.

The three arguments that have been adduced against this view are:—(1) The rounded and apparently rolled pieces of pyrites to which reference has already been made. (2) The circumstance that all the conglomerates are not equally mineralized. (3) The circumstance that ores are said to be poorer rather than richer in the neighbourhood of the eruptive dykes, and that no direct connexion can be traced between the dykes and the mineralization of the conglomerates.

With regard to the second theory, it may be observed that the varying richness of the conglomerates may be explained by the variability in their permeability. All the conglomerate-reefs are mineralized and carry some gold, and it is currently held that the reefs with coarse pebbles and smoke-coloured or bluish-grey cement are the richest; this seems to show that those beds are the richest in which the widest interstices were filled exclusively with cementing-material.

As to the third theory, the only direct evidence of the connexion between the mineralization of the conglomerates and the eruptive rocks is to be found in the presence of talc and chlorite in the cementing-material, whilst these minerals do not exist in any of the wall-rocks. It is in nowise proved that the reefs are poorer in the neighbourhood of the eruptive dykes, whilst the author knows of several cases where exceptionally rich ores were found in immediate contact with them.

Lydenburg.—The best proof of the influence of eruptive rocks is to be found in the Lydenburg district, and notably at Pilgrim's Rest. The dolomite formation, interbedded with sheets of trap, is practically a reproduction of the classical formation of Derbyshire, except that the beds of galena of the latter are replaced by auriferous bedded deposits of quartz. The dolomites of Lydenburg rest upon clay-slate and this upon sandstone, the lower beds of which contain the deposits of coal, which outcrop to the south of Middelburg. There are numerous sheets of trap interbedded with the dolomite, and occasional bedded deposits of quartz which are rich in gold near the trap-rock, and chiefly where this rock is much decomposed. The various gold-bearing quartz-beds do not occur at the same levels in the dolomite formation.

De Kaap.—The De Kaap district consists of sedimentary formations, striking about east-and-west with a steep dip to the south, and are bounded to the north and south by granites; they consist, from foot to hanging-wall, of chloritic slates, quartzites, clay-slates, conglomerates and sandstones; conglomerates being, however, rare. Near the centre, the entire formation has been violently heaved towards the south, a phenomenon, no doubt, connected with the occurrence of eruptive rocks at this point. This break divides the field into two parts, the Sheba district in the east and Moodie's in the west. On Moodie's, the veins run near the contact of eruptive rock with chloritic schists, and consist of milk-white quartz carrying free gold, threads of auriferous pyrites, and in places gold-bearing tellurides.

In the Sheba district, the Sheba mine is the only one of any importance. The district is characterized by numerous bars of quartzites that form either the foot or the hanging-wall of the auriferous deposits. All the strata are here traversed by numerous north-and-south cross-veins, apparently fissure-veins, and the author thinks that these, though not themselves rich, form pay-shoots where they intersect the bedded deposits. The shoot of the Sheba is about 165 feet along the strike, and its real thickness is not yet known, for although its hanging-wall is well marked by a heavy bar of quartzite, explorations on the foot-wall side are constantly revealing additional belts of rich ore. Other mines in this district that may do well in the future are the Swartkopjes and the Woodstock. It seems probable that the masses of granite to the north and south unite in depth, and thus form a basin limiting the workable quantity of these deposits, but only at a very considerable depth. H. L.

(6) *Ein Beitrag zur Kenntniss des Umtali-Districtes* (*Manica, Mashonaland*). *By* Dr. K. A. Redlich *and* A. v. Dessauer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., page* 1, *and plates.*

Umtali, Mashonaland.—The geological structure of the Umtali district consists of steeply inclined layers of Primary slates, probably coeval with the Swazi schists, striking from east to west for a length of some 60 miles along the Sabi river; the

belt is about 10 miles broad at the extreme east, but wedges out in the west, passing on the north into granite. Parallel to the slates, basic massive igneous rocks occur; both formations are traversed by greenstone-dykes and felspar-porphyries; serpentines and quartz-porphyries also occur.

Three types of quartz-veins occur, all parallel to the stratification and gold-bearing:—(1) Veins in talcose (or other) slates; *e.g.*, the Penhalonga reefs, characterized by the occurrence in them of crocoisite, the Revue, Champion, Grand, etc., reefs; (2) veins at the contact between granite and slate, *e.g.*, the Agency, Grand Manica, Quagga, etc., reefs; and (3) veins in basic rocks, *e.g.*, the Rezende, Orphan, Princess May, etc., reefs. The future prospects of this district seem to be developing satisfactorily. H. L.

(7) *Une nouvelle Théorie sur l'Inclinaison des Couches aurifères au Witwatersrand. By* F. Schiff. *Le Génie Civil*, 1896, *vol. xxx., pages* 87-89, *and sections of mines.*

Witwatersrand.—The beds of auriferous conglomerate which constitute the stratification of the Main reef series owe their industrial value to their regularity in the mines worked on the outcrop; but it was afterwards found that their continuity was interrupted in places by faults and dykes. Mr. Carrick lately pointed out in a communication to the Geological Society of South Africa that these fractures result from forces, the nature and direction of which may be determined with greater or less exactitude by an examination of the relative positions of the fault-planes and the seams surrounding them. The author reproduces Mr. Carrick's arguments, and gives nine sections of gold-mines, concluding that it would be easy to multiply such examples as appear to bear out the hypothesis advanced.

J. W. P.

GOLD DEPOSITS OF MADAGASCAR.

L'Or à Madagascar dans le sud de Betsileo. By C. Chauveau. *Le Génie Civil*, 1897, *vol. xxxi., pages* 5-8, 20-22, *map and sketches.*

Although Madagascar has long been known to produce gold in moderate quantities, the greater portion of it was obtained by forced labour, or by irregular native work, under conditions that would not be possible in modern methods. Of the geology of the island only the outlines are known; the entire central portion consists of red, rather friable earthy rock, evidently of eruptive origin, and doubtlessly due to the slow decomposition of a felspathic and hornblendic rock. This is traversed by important outbursts of granite and by basaltic dykes, and is overlain by strata of Jurassic, Cretaceous and Tertiary age. Gold is widely distributed throughout the island; the only other known mineral deposits so far are an unimportant copper-mine near Ambositra, some deposits of galena, the outcrops only of which are known, a thin bed of lignite of Jurassic age at Amboratoby, and wells of bitumen discovered near Ambohitsalika. No Carboniferous strata have been met with, and there is accordingly no prospect of finding any true coal.

The district of Betsileo seems to be the most important as a gold-bearing district: the auriferous deposits consist of alluvials and of disseminations. No vein of gold-quartz has yet been met with, and all the quartz-pebbles occurring in the alluvials are barren, carrying neither sulphides nor free gold. The alluvial deposits form the bottom of river-valleys, and also the beds of actual streams. The gold is always very fine, none bigger than a pin's head having been found. The section of these deposits is generally similar: the gold-bearing sands and gravels are overlain by layers of clay and a bed of peat, and rest often upon a bed

of white clay due to the decomposition of pegmatite. The bed-rock proper is granite or mica-schist. The gold found *in situ* is in the above-named red rocks: these are everywhere slightly auriferous, and in some places the gold seems to be concentrated in certain zones, forming thus true stockworks. These deposits are known about Itola, where the richness of the deposit varies from 0·83 gramme to 2·49 grammes per cubic metre (10 to 30 grains per cubic yard). At Vinanitelo, Vohibé, Lomaku, etc., alluvial deposits are known; their thickness varies from 8 inches to 4 feet, and their richness ranges from 6 grains to exceptionally 40 grains of gold per cubic yard. H. L.

DISPUTED GOLD DISTRICT OF BRAZILIAN GUIANA.

Der strittige Golddistrict von Brasilianisch Guyana. *By* Dr. Friedrich Katzer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 295-300.

Between the Brazilian and the French Guianas, there is a strip of territory claimed by both nations; it consists mainly of a gold district lying between the river Oyapoc on the north and Aragury on the south, from which the smaller streams Cassiporé, Cunany, Calçoene, Amapa, and Tartarugal take their rise and flow north-eastwards to the Atlantic. The district is hilly, with swamps to the eastward. Little is known of the geology of the country, the main rocks being apparently granite and gneiss of various kinds, traversed by dykes of greenstone. Gold apparently occurs in all these rocks, but mainly, it would seem, in conjunction with quartz. The gold is, however, obtained from apparently recent alluvial deposits from the earthy and swampy ground, and seems to accumulate about the roots of certain plants. The annual output of Brazilian Guiana may be taken as over 1,326 kilogrammes (42,640 ounces); there are said to be 3,000 men at work at present, principally on the Upper Calçoene. The district is said to be very unhealthy, and life and property extremely insecure. H. L.

MINERAL REGIONS OF BRITISH COLUMBIA.

By H. M. Beadle. *The Engineering and Mining Journal* [*New York*], 1896, *vol. lxii., pages* 104 *and* 105, *with* 2 *ink-photo illustrations.*

The mineral region of south-eastern British Columbia is extensive; but the author confines his description to the country within a few miles of Rossland.

The country-rock is a hard diorite, from greenish to almost black in colour. Veins traverse the rock in almost every direction, but the veins which have been most explored have easterly and westerly strikes. On the surface, the veins are covered by an iron capping, and so far, in breaking through this capping from a few feet to less than a hundred feet, ore has been found north of Trail Creek, carrying gold and a small quantity of silver. South of that creek, the ores are principally argentiferous galena, carrying some gold. No galena has been found north of Trail Creek, but molybdenite is common to some veins. There has been only one vein found carrying free-milling gold, and that is in diorite also. The gold is found in copper and iron pyrites, arseno-pyrites, white and magnetic iron. As a rule, the copper pyrites is the richest in gold, but there are many exceptions. The veins are large, and become larger as depth is attained. This seems to be a law of the district, and the ore-bodies also get richer in depth. The Le Roi shaft is now down 475 feet on the incline (over 300 feet perpendicular), and the bottom of the shaft is in the richest ore yet encountered in the mine. As a rule, the ore is richest on the hanging-wall.

The size of some of the veins is almost incredible. The Le Roi vein, at the 350 feet level, has seven sets of timbers side by side, and no walls have yet been reached. The net value of the ore in this mine now in sight is said to be £600,000, whilst the ore in sight in the War Eagle vein has been estimated at considerably over £200,000. In the latter vein, a great part of the ore has been estimated to contain £15 value per ton in gold and silver, and also to carry 8 per cent. of copper. The Centre Star also shows a rich vein, and large bodies of ore are found in the Jumbo, Cliff, Iron Mask, the Columbia, and a dozen other mines in the north of the creek. The ore-bodies in the mines south of the creek are said to be very large also. If the mines having large veins should show ore as good as those mentioned, the camp will be one of the greatest gold-producers in the world.

Induced by the rich ores of the district, the British Columbia Smelting and Refining Company has erected a smelter at Trail, 7 miles from this camp, on the Columbia River. There are four reverberatory and two blast-furnaces. The matte, which contains both copper and gold, is shipped to the smelter of the Montana Ore Purchasing Company, at Butte, where it is mixed with the ores reduced at that smelter.

In Trail Creek district there are two towns—Rossland, at the head of the creek, 3,800 feet above the sea, and Trail, at the mouth of the same creek, 1,400 feet above the sea. These towns are connected by a narrow-gauge railroad, with trains twice a day. Trail is connected by steamers with Northport, Washington, on the Spokane and Northern railroad, and with the Canadian Pacific road, which has a branch to the head of Arrow lake, through which the Columbia runs.

Rossland is a town of 5,000 people, about 1,500 of whom find employment in the mines. It has waterworks, electric lighting, and is supplied with business houses and hotels. Work has been begun on a railway which will connect Rossland direct with Northport, when there will be continuous railroad service to all parts of the United States.

Trail is a town of about 800 people. J. W.

THE GOLD QUARTZ-VEINS OF NEVADA CITY AND GRASS VALLEY DISTRICTS, CALIFORNIA.

By WALDEMAR LINDGREN. *U.S. Geological Survey: Seventeenth Annual Report of the Survey* 1895-96. *Part II. Economic Geology and Hydrography, pages* 14-262, 24 *plates, and* 37 *illustrations.*

The first find of gold-bearing quartz in this district was made in 1850. A rich ore-shoot was struck by miners while digging a hole for their cabin-chimney, and pieces of the vein were found containing 100 ounces of gold per ton. The first mill was erected in January, 1851. From 1853, the fortunes of the district have varied considerably, but in 1893 there were 385 head of stamps, and several new mills have been erected since then.

The ores are free-milling, but a small fraction of sulphides is also present, containing a certain percentage of gold. The free gold is recovered by amalgamation (mostly in the battery), and the sulphides are concentrated by means of vanners.

To extract the gold from the concentrates, the chlorination process is used. The cyanide process was tried, but has not yet been found successful. The cost of milling varies from 2s. to 4s. per ton. Chlorination costs about 36s. per ton of concentrates. The cost of mining ranges from 10s. to 20s. per ton. The power used is steam, water, or electricity.

Some mills save as much as 90 per cent. of the assay value, but in the majority not more than 75 per cent. is recovered. The total product of gold cannot be stated accurately, but it is estimated to be over 50,000 ounces per annum.

The country rock (known locally as "Bed Rock") consists of slaty sedimentary rocks, together with diabases and porphyrites, with enormous intrusions of coarse-grained granitic rocks. Many parts have a pre-Cambrian aspect, although it is certain that they are of much younger age. No fossils have been found in the sedimentary rocks of the district. The Carboniferous strata doubtless predominate, but there are also deposits of the later Jura-Trias period. The forming of the mineral veins was the last phase of the Mesozoic evolution. During the later part of the Neocene period volcanic material began to pour down through the valleys, and ultimately a sheet of lava covered the whole district. During this volcanic period the Sierra Nevada was subjected to a tilting uplift which at the summit probably amounted to several thousand feet, and the streams at once began the work of cutting into this desolate lava-plateau. In the district described in this folio, the sloping ridges—Harmony ridge and Banner-Hill Towntalk ridge—are the only remnants of the lava-sheet which once covered the whole region, while the present watercourses are sunk several hundred feet below the Neocene surface. Underneath the remaining portions of the lava sheet, the channels of the Neocene rivers have been found, containing in many cases important deposits of auriferous gravel.

A detailed geological examination of the district has been made, and the author gives a very minute description of each formation.

The ore occurs in fissure-veins, and the gold is found in pay-shoots of an irregular form. When the shoots are small they are called pockets or chimneys. The pay-shoot usually pitches at a steep angle on the plane of the vein. The following law appears to govern the general direction:—The shoot will, as a rule, pitch to the left of an observer standing on the apex of the vein, and looking down in the direction of the dip.

No relation can be established between the direction of the pay-shoots and the direction of the striation on the walls. Some of the veins pinch out at varying depths, but others continue to the deepest levels. The pay-shoots do not all come to the surface. For instance, a small shoot of ore was recently found at the bottom of a shaft 2,200 feet deep. Observations in a mine, at a depth of 1,523 feet, showed a temperature of 66° Fahr. in a damp bore-hole, and the air in the stopes had a temperature of 69° to 70° Fahr. The average annual temperature at the surface is supposed to be about 59° Fahr., but at 30 feet below the surface the temperature of the rocks was 53·5° Fahr.

The folio closes with a detailed description of the mines in the district, illustrated by numerous plans and photographs. R. W. D.

GREAT MOTHER LODE OF CALIFORNIA.

By Harold W. Fairbanks. *The Engineering and Mining Journal* [*New York*], 1896, *vol. lxii., pages* 248-250, *and map.*

The map given shows the course of the lode from Eldorado county to Mariposa. If we examine a geological map of the Sierra Nevada we see that, beginning in Mariposa county and extending northward until covered by the volcanic rocks in Plumas county, there is a widening belt of slates with associated dykes of eruptive rocks which are known as the Bed Rock series. Gold-bearing quartz-veins occur over much of this area, and these can be separated into three general divisions, the lower, middle, and upper belts. The middle one is the most regular and con-

tinuous, and by far the most productive through most of the counties on the western slope of the Sierras. It is the one to which custom is almost unanimous in assigning the term "mother lode."

This lode may be defined as a mineralized zone of varying width, sometimes reaching over a mile, and extending continuously through the counties of Mariposa, Tuolumne, Calaveras, Amador and El Dorado, and possibly farther north.

As far as can be learned, the term "mother lode" was first applied to the veins worked at Nashville, 12 miles south of Placerville, in the latter part of 1850 or earlier part of 1851.

The magnitude of the operations on the mother lode gold-belt since the earliest days of mining in California, are best shown by the fact that over the whole length of the lode, a distance of over 100 miles, there is an almost continuous series of mines, comprising more than 500 patented claims, and almost as many unpatented ones.

The lode follows in a general way the north-west and south-east trend of the mountains, the veins conforming usually to the same dip as the enclosing stratified rocks, viz., 40 to 75 degrees. There is, without doubt, no such series of gold-bearing veins as the mother lode to be found elsewhere in the world. While the number of patented mines already exceeds 500, mining here is yet in its infancy. With more careful exploitation, and better means of saving the gold, many more mines can be worked. J. W.

GOLD-FIELDS OF AUSTRALASIA.

By Oberbergrath Karl Schmeisser, *assisted by* Dr. Karl Vogelsang. *Die Goldfelder Australasiens, pages ix. and* 165, *with* 25 *illustrations,* 13 *maps and plates and numerous tables. Berlin,* 1897, *Dietrich Reimer.*

The first 30 pages are devoted to a brief geographical and physiographical description of Australia, Tasmania and New Zealand, followed by general remarks on their history and economical development.

Then follows (pages 31-36) a short geological description.

Australia (Plate II., geological map, 1/12,000,000 from the official maps of the colonies, revised by Mr. C. L. Wilkinson, geologist of New South Wales) is largely built up of members of the Archæan formations (crystalline schists, gneisses and phyllites, with granite, syenite, diorite, etc.), which, especially the granite, constitute the foundation, and are particularly prominent in the west of the continent. Mr. H. P. Woodward distinguishes in Western Australia five Archæan zones:—(1) A western band of slates and quartzites with granite-intrusions; (2) gneiss and mica schists with granite and felsite-outbreaks, extending from the south coast to Lyons River; (3) main granite zone, about 100 miles from the west coast and as many broad, from the south coast to Murchison River; (4) first auriferous zone, composed of mica and talcose schists, with amphibolites, granites and diorites, about 20 miles broad, extending from the south coast *via* Ravensthorpe, Parker, Southern Cross, Golden Valley, Mounts Jackson, Kenneth, Magnet and Lake Austin to Cue in the Murchison district; (5) second granite zone, about as broad as the first, from the south coast up to Fortescue River. To the east of zone 5 appears a second auriferous zone of the same nature as the first, the eastern limit of which is still unknown, and which extends from Dundas Mountains in the south, *via* Wagemulla, Coolgardie, Three Pinnacles, Ullaring and Lake Carey to Marble Bar and Pilbarra on the north-western coast. The Archæan rocks and old eruptives are also prominent in the central islands (MacDonnel Mountains), and constitute the heart of the eastern chains from Victoria to Queensland (Cape York).

The Palæozoic formations are also widespread: Lower Silurian (? Cambrian) is chiefly developed in western Victoria; Upper Silurian in the east of Victoria and in a large part of New South Wales and South Australia. Devonian is conspicuous in New South Wales, and constitutes in the Kimberley district of Western Australia the Carr Boyd and Albert Edward Mountains. Carboniferous is chiefly developed in New South Wales and Queensland; in Western Australia it appears on the Irvine and Collie rivers, as also in the Kimberley district: valuable coal-beds exist in the three colonies.

Of the Mesozoic, Triassic is represented in New South Wales by the Hawkesbury Sandstone; Oolitic limestones and ferruginous clays with Jurassic fossils are found in the Victoria district of Western Australia, while the Cretaceous appears in Western Australia, in the west of Queensland, as well as in the so-called Desert Sandstone of the central regions.

Tertiary sediments are represented in all the colonies, often interrupted by basalts, andesites and other eruptives. Diluvium and alluvium are widespread in the plains of the interior as in the water-courses of the coasts.

Tasmania (Plate III., geological map, 1/100,000, after Messrs. Gould, Johnston and Sprent) is, at the base, a continuation of the Silurian formations of eastern Australia, interrupted by extensive granite-bosses. The Carboniferous, alternating with diabase-sheets, overlies the Silurian, while Tertiary sediments and basalts are represented in the north and south of the island.

New Zealand (Plate IV., geological map, 1/3,200,000, of Sir James Hector, 1885) has a mountainous backbone of crystalline schists, granite, and Palæozoic sediments. To the west the chain falls abruptly, while to the east its flanks are covered by Mesozoic strata. In the south-east, the highland of Otago is made up of Archæan and Silurian rocks, and in its valleys, as well as east and west of the main chain, thick Tertiary gravels are conspicuous. The coal-seams of Reefton and Brunnerton and the Eocene lignite of Oamaru are of great economical importance. A special volcanic feature in the geology of the North Island, to the west and north-west, is due to the repeated eruptions of trachytes and andesites during and since Tertiary times. The volcano Tongariro (7,515 feet) is still active, while further north, in the region of the hot-lakes, mud-eruptions, geyser-phenomena, and solfataras—to say nothing of the Tarawera catastrophe in 1886—also testify to the continuance of volcanic energy.

Pages 36 to 109 of Dr. Schmeisser's report describe the distribution and mode of occurrence of gold in Australasia. The names of the principal gold-fields are printed boldly in red on the maps above-mentioned, so that their geographical distribution is seen at a glance.

Australia.—In Queensland, there are the Gympie, Charters Towers, Crocodile, Etheridge and Croydon gold-fields, with others of minor importance, such as Ravenswood, Palmer, Hodgkinson, etc. In New South Wales, gold has been discovered and worked in so many localities that only the most prominent are mentioned. They are, in the north, the New England, Clarence and Richmond, Peel and Uralla, and Hunter and Mackay districts; in the west, the Mudge, Tambaroora and Turon, Bathurst, Lachlan, Cobar and Albert districts; in the south, the Tamut and Adelong, and the southern districts. Victoria numbers seven gold-fields, to wit, Bendigo, Castlemaine, Maryborough, Ballarat, Ararat, Beechworth, and Gippsland. South Australia has no extensive gold-fields, and only the "finds" of Teetulpa, Mannahill, Barossa, Mount Pleasant, Gumaracha, Hahndorf, Echunga, Jupiter Creek, and others in the southern territory, and that of Port Darwin in the northern territory are mentioned. In Western Australia, twelve gold-fields have, so far, been proclaimed:—Dundas, Coolgardie, East Cool-

gardie, North Coolgardie, Yilgarn, Yalgoo, Murchison, East Murchison, Ashburton, Pilbarra, West Pilbarra, and Kimberley. Dr. Schmeisser gives the longitude, latitude, extent, and chief townships of most of the above continental gold-fields.

Tasmania has three gold districts: (1) North Coast, with the Tamar field and the Lefroy, Pipers River, Back Creek, Lisle, Denison, and Golconda finds; (2) North-eastern, with the Mangana and Mathinna fields, and the Waterhouse, Gladstone, Mount Horror, Branxholm, Mount Victoria, and Scamander finds; (3) West Coast, with the finds of Piemans and White River, Port Macquarie, King River, and Mount Lyell, and those of the streams that run into Port Davey.

New Zealand also numbers three auriferous districts: (1) Hauraki, on the North Island, comprising the Coromandel peninsula and the land to the south as far as Waiorongomai; (2) West Coast of South Island, from Cape Farewell to the Wanganui River, with the Reefton and Lyell lodes, and the auriferous gravels of Collingwood, Westport, Kumara, Hokitika and Ross; (3) Otago in the south-west of South Island, with various Primary and Secondary deposits.

After this brief geographical review, Dr. Schmeisser considers the occurrence of gold from a purely geological standpoint, grouping the repositories—irrespective of locality—according to the geological age of the formations in which they are found. In Australasia, gold exists in all the geological formations but, with few exceptions, it can only be mined profitably in the Archæan, the Primary, and the Tertiary. Its mode of occurrence is very varied; disseminated in igneous rocks, in lodes, in beds, and in alluvia of different ages; but by far the most frequent mode is that of lodes or veins, either fissure or bedded, contact-lodes being rare.* An interesting table gives a summary or synopsis of this geological classification and mode of occurrence.

ARCHÆAN GROUP.—Auriferous Veins in Crystalline Schists.—They occur frequently in chloritic schists, amphibolites, talcose and sericite-schists in many gold-fields of Western Australia, South Australia, New South Wales, and Queensland, chiefly as bedded veins, but also as fissure-veins. As almost all pre-Carboniferous rocks have a mean north to south trend, the bedded veins usually partake of the same. This is also, generally speaking, the case with the veins and dykes of igneous rocks (diorite, diabase, felsite and porphyry).

Western Australia.—The country-rock of a large number of auriferous lodes is called "diorite;" but although there are some true diorites in the Murchison district, the microscopic examination of many fresh specimens proves the majority to be amphibolites. As they form massive beds in the midst of the crystalline schists, they might genetically be classed with these; it is, however, by no means improbable that they are metamorphosed diabase-dykes, and the question as to their origin must, for the present, remain open. Mica-schists, phillites, and talcose schists also occur as country-rock of gold-veins in Western Australia.

The veins strike chiefly north-north-west to south-south-east, or north to south, or north-north-east to south-south-west, with westerly dip. Locally, they constitute groups or trains. There are two kinds:—(*a*) Simple quartz-veins, the only essential gangue of which is quartz; and (*b*) compound or complex veins locally termed "lode formation," the filling of which consists of more or less decomposed country-rock, intersected by numerous quartz-veinlets or stringers. The quartz-veins proper cross "country" in all directions, but chiefly north and south, with slight variation to east or to west. They vary greatly in thickness, from ½ inch to 40 inches, attaining sometimes 30 to 80 feet; and in each single vein the thickness varies frequently both on strike and on dip; the walls are generally well defined.

* We purposely avoid the use of the new-fangled term *reef*, which is as inappropriate as it was needless.

Some appear as lenticular lodes as, for instance, in the Edjudina group (North Coolgardie), where each vein consists of a row or train of quartz-lenses, more or less separated from one another. The quartz of these simple veins is white, grey, brown, yellowish, greenish, or blackish, and is often cellular or drusy. The compound veins vary in thickness from 3 to 70 feet or more, and this dimension is very changeable in each case. With few exceptions, they have, as yet, only been explored in the upper or decomposed zone, and therefore are filled, partly with a red, brown, or yellow ferruginous clayey stone, partly with white, yellowish, or reddish kaolin. In the Kalgoorlie field, this filling is traversed, usually from east to west, by white, grey, brown, greenish, or black quartz-stringers of varying thickness; the greater their number and the more cellular or spongy the quartz, the richer the lode as a rule. In the majority of cases, only the foot-wall of these lodes is defined; on the hanging-wall, the filling merges gradually into the "country;" slickensides are frequent on the foot-wall and in the lode itself.

Whereas the simple quartz-veins occur in all the Western Australian districts, the compound veins, so far as yet ascertained, are confined chiefly to the Kalgoorlie, Broad Arrow, Bardock and Bulong groups of East Coolgardie. However, in the Menzies, Yalgoo, Mount Magnet, and other groups, some more or less typical veins of this class have been discovered. The best mines of Kalgoorlie (Great Boulder, Lake View, Ivanhoe and Hannan's Brownhill) are on compound veins.

The quartz-veins proper are, for the most part, easily traced at the surface by conspicuous outcrops or the loose *débris* of the same; but the compound veins only offer, at best, some indication in the iron-stained ground The lodes striking east-and-west are, as a rule, inferior to the north-and-south lodes in extent and value.

Gold is found, not only in the quartz-veins proper and in the stringers of the compound veins, but also in the filling mass of the latter. In the first, it may average from 1 to 2 ounces per ton; in the stringers, from 1 to 4 ounces or more; but in the mass or filling, it ranges from mere traces up to 1 ounce at most. A few crushings have been reported with 3, 5, and even 15 ounces of gold to the ton. Usually, the gold is in a very fine state of division, and cannot be seen. Visible gold is, however, often met with—in the compound veins, as a fine powder, or in specks or spangles, or as a soft mosslike or spongy deposit which may be wiped off with the finger, or in thin plates or thick, irregular nuggety bits. In the quartz-veins proper, with yellow, brown, or grey quartz, the gold is usually finely disseminated throughout, while in milk-white quartz it commonly appears in spangles or irregular nuggets in the fissures; white quartz with glassy lustre is very poor. As a rule, the gold is concentrated in shoots, which are sometimes extraordinarily rich, though within a given shoot, the gold contents may vary considerably; outside the shoots, a lode may be entirely unproductive. In many cases also a concentration of gold has taken place in isolated patches or pockets near the surface, while at even a very moderate depth the lode rapidly impoverished, as in the case of the Londonderry and Edjudina mines. The silver content of the gold is inconsiderable.

The associated minerals met with in the lower, undecomposed zones of the lodes are iron and arsenical pyrites; here and there a little galena, and rarely chalcopyrite; in the upper parts, the products of decomposition of these minerals are found. Recently, tellurides of gold (sylvanite, calaverite, krenerite) have been met with in the compound veins of Kalgoorlie, Broad Arrow, Bardock, and Bulong, below the gossany or decomposed zone, *i.e.*, at a depth of 150 to 250 feet. Tellurides of silver (petzite, hessite, etc.) invariably accompany them, and they are usually associated with pyrites.

The depth of the decomposed zone varies considerably. For instance, in the Cue district, it averages 60 to 100 feet; and in Menzies and Kalgoorlie, 130 to 180 feet. The "country" is usually decomposed to the same depth as the veins. Cross-veins, either auriferous or of igneous rock and faults, with their disturbing influence, are met with, but are not frequent.

As to the genesis of the Western Australian lodes:—As a rule, the simple quartz-veins, as well as the compound veins, may be regarded as mineralized fissures, the opening of which gave rise, in most instances, to a displacement of the sundered rock-masses; the only difference is that, in compound veins, larger parts of the rock have been shattered and crushed and now constitute the filling or "formation." Between the two extreme lode-types, other intermediate ones may be studied in all stages of development; they are, as a rule, much poorer than the typical compound veins, which fact does not prevent the Western Australian miner from applying to them the term "lode formation" in order to enhance their value!

As to the question of value in depth, below the decomposed zone, the Ivanhoe, Great Boulder, Boulder Perseverance, and Lake View lodes may be quoted as instances of compound veins maintaining their value in the undecomposed or pyritic depths; on the other hand, several compound veins have greatly pinched and impoverished, or even completely wedged out, on attaining the undecomposed level. Finally, Dr. Schmeisser cannot admit, for the present, the recently propounded theory, that the telluride lodes are the outcome of igneous or eruptive action.

New South Wales.—The conditions of the auriferous lodes in the crystalline schists of this colony are similar to those of the simple quartz-veins of Western Australia and call for no further notice.

Some repositories of Peak Hill, in the Mudgee district, may be considered as compound veins: they occur in talcose schist, without defined walls, one of them, for instance, being made up of 7 feet of ferruginous quartz and quartzose talc-schist, 10 feet of talc-schist, 7 feet of quartzose talc-schist, 23½ feet of talc-schist and 3 feet of the same with ferruginous quartz-stringers; several samples of this lode yielded 1¼ to 10¼ ounces of gold per ton, which, as a rule, is not visible. In the Caloola field, Bathurst district, gold occurs, not only in the quartz-lenses between the layers of the mica-schist, but also in the schist itself close to the quartz; in some cases barren quartz-lenses have been found between auriferous layers of schist.

Auriferous Lodes in Granite.—A large number of gold-veins in many localities occur in granite which is, in the great majority of cases, of Archæan origin. Although younger auriferous granites may exist, their age is so difficult to determine that they will be considered in this place with the older ones. The lodes of the Croydon and Etheridge fields in Queensland, those of Wagonga in New South Wales, and those of Ararat in Victoria, occur in normal granite, while the lodes of Charters Towers, Ravenswood, and other fields of Queensland, and those of Armidale (in part), Yalgogrin, Wyalong, Gundagai, Tumut, Adelong, Braidwood, Garangulah, Majors Creek, and others of New South Wales are found in hornblende-granite.

Queensland.—In the Croydon field, both hard, solid granite and highly decomposed granite, with graphite, occur side by side, but, so far, auriferous quartz-veins have only been discovered in the decomposed rock. They mostly strike north-north-west and dip to the north-east, have great length, a width of 2½ to 6 feet, and are, in general, tolerably regular. The gold occurs chiefly in a free

state, largely alloyed with silver, so that it is not worth more than 47s. per ounce; in depth, iron and arsenical pyrites, and sometimes galena, appear. The most important lodes are the Iguana, Golden Gate, and Queen.

In the Etheridge field, the lodes strike east-and-west, and dip to the north, the decomposed zone is 65 to 80 feet deep, and below it the auriferous quartz contains iron and arsenical pyrites, and a little zinc-blende and galena. In the now shut-down Cumberland mine, the lode impoverished at the 600 feet level, and appeared to wedge out at the 850 feet level. The principal mines are the Nil Desperandum and the Queenslander; in the former, the lode has been proved over a length of 1,700 feet, and is said to average $1\frac{3}{4}$ to 2 ounces of gold per ton, but the crude gold is not worth more than 57s. per ounce.

Charters Towers.—The hornblende-granite of this field is intersected by numerous auriferous veins and others of felsite and diorite, the first of which strike in very different directions, though their dip is chiefly to north. The width of the gold-veins also varies considerably, but averages about 3 feet, and many of them show no outcrop. The gangue is quartz and decomposed "country;" near the surface the visible gold is accompanied by limonite; in depth it is much finer, and occurs with much iron and arsenical pyrites, and but very little galena and zinc-blende. The principal mines are on the Brilliant lode, the gold content of which varies considerably: 1 to 2 ounces per ton were formerly frequent, but the deepest levels (2,000 to 2,300 feet) only yield $\frac{3}{4}$ ounce.

Besides Charters Towers, the only important field of Queensland in hornblende-granite is that of Ravenswood, where the gold content varies from 186 to 354 grains per ton. Accessory minerals are chalcopyrite, arsenical pyrites, and zinc-blende.

New South Wales.—Wagonga field.—In Mount Dromedary, a quartz-vein of 1 to 12 inches strikes east-north-east through decomposed granite. The auriferous quartz carries much iron pyrites, which is decomposed as far down as the granite. Outside the vein, the decomposed rock is often sufficiently auriferous to be worth milling.

In New South Wales, the gold-fields already-mentioned offer, in general, great similarity, and in most of them the hornblende-granite is traversed in different directions by many auriferous lodes of the lenticular type, which is particularly marked at Garangulah. The width of the lodes varies from a few inches to 7 feet; the filling consists of auriferous quartz with limonite and sometimes oxides of manganese and copper, malachite, chessylite, galena, cerussite and wulfenite in the upper levels, and of auriferous quartz with iron and arsenical pyrites, chalcopyrite, zinc-blende and galena below the decomposed zone. The gold is usually freely disseminated and in shoots, sometimes coarse near the outcrop, and varies much in quantity. Some lodes have proved profitable at considerable depths, while others, rich at the surface, have impoverished or disappeared at the lower levels. In some lodes of the Wyalong field, nodules occur, composed inwardly of arsenical pyrites, which passes, towards the outside, into limonite with minute specks of visible gold. Small yet visible spangles of gold are also met with in the granite out of the lodes.

Auriferous Lodes in Quartz-diorite.—In the Murchison field (Western Australia) to the north and south of Cue, a wide region, is taken up by quartz-diorite limited to the east and west by crystalline schists; it is much decomposed to a depth of 90 to 110 feet, forming a friable kaolinic mass, usually white, but often brownish; but below these depths the rock is comparatively fresh. It is traversed in different directions by a number of lodes, averaging 3 to 4 feet in width, composed of irregular lenticular quartz-bodies, between which and the usually well-

defined walls a selvage of quartzose kaolin often appears, due to the decomposition of the diorite. The gold occurs chiefly in the quartz, subordinately in the kaolin, generally in a fine state of division, yet sometimes in visible spangles and coarser bits. The gold content, as reported, varies between 1 ounce and $2\frac{3}{4}$ ounces per ton, but as a concentration of the precious metal near the outcrop almost invariably obtains, it is questionable whether the said content will hold out in depth. Besides this, some lodes are very irregular, both in strike and in dip.

Auriferous Lodes in Quartz-porphyry.—North-east of Croydon (Queensland) auriferous quartz-veins occur in felsite, and in the Golden Valley, 18 miles away, in quartz-porphyry. The veins are thin and the gold they bear is finer than that of the granite-lodes, being worth 65s. per ounce as against 45s.

Auriferous Lodes in Porphyrite.—This rock is intersected by many gold-veins in the Black Snake field (Queensland). The gangue is porphyritic, and the ores consist of a mixture of iron and arsenical pyrites, galena, zinc-blende, chalcopyrite, and quartz, with about 1 ounce of gold to the ton. In the porphyrite of the Cargo field (New South Wales), lodes also occur with fine bloodstone in which auriferous pyrite is embedded.

Auriferous Lodes in Syenite.—In Brown's Creek, Bathurst (New South Wales), syenite is traversed at a high angle by several powerful and parallel lodes of ordinary quartz.

SILURIAN GROUP.—All the gold-fields of Victoria belong to this formation, and also important repositories in the Orange, Hargreaves, Hillend, Wellington, Lyndhurst, and other fields of New South Wales, several of the north-east Tasmanian fields and those of Otago, in New Zealand.

Auriferous Sedimentary Rocks.—In Mount Drysdale (New South Wales), siliceous slates, sandstones, and conglomerates are said to occur in which gold is finely disseminated and seldom visible, or is concentrated in shoots yielding from $\frac{1}{2}$ ounce to 30 ounces per ton. Similar auriferous slates are reported from Mount Allen and some mines near Cobar.

Auriferous Lodes.—Victoria is the most important region of Australasia for Silurian gold-veins, chiefly bedded veins. In the Lower Silurian of Ballarat, their gangue is mainly quartz, with sometimes argillaceous, sandy stone, and pieces of more or less decomposed "country." Near the outcrop, the quartz is crumbly or honeycombed, with ferruginous masses, resulting from decomposed pyrite, in which free gold is finely disseminated. In the fresh zone, the gold is, in part, finely disseminated, in part coarse and visible, with iron and arsenical pyrites in large masses here and there. The so-called "indicator-lodes" of this field are specially interesting: the "indicators" are thin beds ($\frac{1}{2}$ to 2 inches) of highly bituminous shale, full of pyrite, parallel to the planes of stratification of the enclosing slates, and, like these, dipping nearly vertically. Their dark colour contrasts with that of the light grey slates, and they can be traced for miles. A great number of quartz-veins cross the slates in every direction, others constitute bedded veins; these latter are poor, but the veins which cut the bedding-planes more or less at right angles average 10 to 15 inches of white quartz, with pyrite, galena and blende, and contain very rich patches of nuggety gold at the line of intersection with the "indicators," although they are, in most cases, quite poor, not more than a foot from the plane of intersection. This concentration of the gold is probably due to the reducing action of the bitumen of the shale on the mineral solutions.

The Cohens lode, near Walhalla, Gippsland (Victoria), deserves special notice for its size, regularity, and richness. It is a compound lode of what appears to be an eruptive gangue, intersected by numerous quartz-stringers, and is worked to a depth of 800 feet. Here, as elsewhere in the colony, the Upper Silurian rocks are

traversed by powerful diorite-dykes, which appear to favourably influence the gold content of the lodes. Dr. Murray asserts that in Victoria, as a rule, the Lower Silurian lodes are more numerous, stronger, but poorer, than the Upper Silurian. In 1890, the average of the millings was: Beechworth 13½ dwts. and Gippsland 15 dwts. per ton, against Ballarat 7½ dwts., and Bendigo 9 dwts. per ton.

The folding or corrugation of the Lower Silurian slates and sandstones of Bendigo has led to the formation of anticlinal and synclinal deposits of auriferous quartz, resulting most probably from the filling up of spaces opened during the plication. These "saddle-lodes" are so well known after the able descriptions of Messrs. Dunn and Rickard that a repetition is unnecessary. Eleven parallel anticlines, with auriferous saddle-lodes, have been discovered, but only three are worked extensively: the New Chum, on a length of 13½ miles, and to a maximum depth of 2,964 feet; the Garden Gulley, 6¾ miles and 2,128 feet; and the Hustlers, 5 miles and 1,850 feet. In some cases, the saddle-lodes are superposed at short intervals, in others they are few and far between. Thus, within a depth of 2,400 feet the shafts of the New Chum and Victoria mines have traversed 30 saddles, while in the 180 Mine only 5 were found. Mining is chiefly confined to the anticlines, though similar gold-bearing quartz-masses have been found in the synclines or inverted saddles; they appear, however, to be less numerous and poorer than the saddles. The gangue is usually white quartz, in which fragments of "country" frequently occur. The gold is very irregularly disseminated, and not all the saddles can be mined to profit. Accessory minerals are iron and arsenical pyrites, and occasionally zinc-blende and galena.

Besides these important repositories, the Silurian formation of Bendigo contains fissure-veins, network quartz-deposits, and ore-bodies, which have often proved rich in gold.

In the Hargraves field of New South Wales several saddle-lodes occur, similar to those of Bendigo, though of minor importance. The discovery of a saddle-lode near Hillend has also been reported.

Near Nerrigundah, north-west of Mount Dromedary, lenticular quartz-lodes have been worked, but although some of them proved very rich at the surface, they have all given out in depth. In the Bywong field, a great number of parallel thin quartz-veins follow the planes of stratification of the Silurian slates.

North-eastern Tasmania.—They do not differ essentially from those of the Australian continent. The most important mine is the Tasmania, near Beaconsfield, with lodes from 1 foot to 16 feet wide, and average gold content of 1¼ ounces per ton, which have been opened up to a depth of 700 feet. But the deepest mine is the Golden Gate, in the Mathinna field, where four strong quartz veins yield on an average 1⅛ ounces per ton, with paying ore at a depth of 1,000 feet.

New Zealand.—Otago District.—A zone, 70 miles broad, of mica-schists or phyllites, considered as of Lower Silurian age, contains many irregular, more or less lenticular, quartz-beds. Not only many of these bedded veins, but also a number of true fissure cross-veins, have proved auriferous. The gold content varies considerably, but averages less than 12 dwts. per ton, though very rich ore has been found in places. Iron pyrites is common, and antimonite, zinc-blende, and galena sometimes occur. In the south-west of Otago, on Wilson River and Preservation Inlet, Lower Silurian quartzites, sandstones and bituminous or graphitic slates are to the fore. Where these rocks are in contact with the granite they are transformed into quartzose mica-schist, which is more or less auriferous.

Gold in Igneous Rocks.—*New South Wales.*—On the left bank of the Bellubula river, between Mandurama, Ponds Creek and Marangulla Creek, and also further

north, in the Frenchman and Cornishman fields, zones of altered diorite occur in which pyrite and gold are disseminated. They strike north-east to south-west, dip 20 to 30 degrees to the north-west, vary greatly in width, and are composed of a mouldy, argillaceous or siliceous, reddish or yellowish-brown mass, in which gold and silver are so finely distributed as to be nowhere visible. The gold content is also very irregular, so that parts worth 1 to 2 ounces per ton alternate with barren parts, and the average must be very small. Here and there the precious metals are concentrated in pockets with iron and arsenical pyrites. The country is traversed by dykes or veins of diorite of more recent date, which have given rise to dislocations in the vicinity of which the auriferous zones have been enriched.

Auriferous fissure-veins repeatedly occur in the diorite-masses of Silurian age; for instance, in the Mitchell's Creek mine, near Daviesville, Mudge district. This lode strikes north-and-south for a considerable length, dips 45 degrees east, and has been worked to depths of 500 to 700 feet on the dip, proving very regular, with an average width of 2 feet. The walls are well defined, and the filling consists of alternate bands of quartz and pyrite, with an average gold content of 15 dwts. per ton. Fragments of the diorite also occur in the lode-mass.

In the Pambula gold-field, Auckland, rhyolite and quartz-porphyry occur together. The rhyolite is traversed in different directions (chiefly north and south) by peculiar veins, composed of irregular, lenticular portions of rhyolite, separated by a soft argillaceous mass. The hanging-wall is usually well defined, with an occasional quartz-leader, while on the foot-wall the lode-stuff gradually blends with the "country." The quartz-leaders contain little or no gold, which is concentrated in fissures of the crushed rhyolite on the foot-wall side, and especially in the intermediate clayey mass. The more the lode-stuff is broken up, and the wider the vein, the richer it proves, apart from the shoots in which, here and there, the gold is concentrated. Pyrites accompanies the ore in depth. The north-and-south lodes are richer than those of other strikes. On the summit of Mount Gahan, the lode yielded 32 dwts. to the ton, and in Pipe-clay Gully ore has been raised with 32 ounces.

In the Wentworth gold-fields and the Aladdin's Lamp mines, near Lucknow, Bathurst, pyroxene-andesite (locally termed diorite) occurs in contact with serpentine. The contact-zone is characterized by a row of calcite and dolomite-bodies, 3 to 4 feet thick, and up to 100 feet long, in which, as also in the neighbouring parts of the hanging-wall serpentine, gold, iron, and arsenical pyrites and native antimony occur. The arsenical pyrites is generally rich in gold, the iron pyrites poor. The ore averages $3\frac{1}{2}$ ounces of gold per ton.

DEVONIAN GROUP.—In the Nundle gold-field, Parry (New South Wales), auriferous quartz-veins occur in Devonian slates, conglomerates, and sandstones, and in diorite and serpentine; several of them pass from the sedimentary rocks into the igneous. These veins vary in thickness from $\frac{1}{2}$ to 12 inches, and carry from $\frac{1}{3}$ to 3 ounces of gold per ton, which is very irregularly distributed in pockets and shoots, and concentrated chiefly where the veins cross clay-slate beds. Similar lodes are found in the Devonian slates and sandstones of Nana Creek, Fitzroy (New South Wales), and of the Mount Poole gold-field.

According to Dr. Wolff, the diorite dykes which traverse the Devonian strata of Queensland, have the same enriching influence on the auriferous lodes as the diorites of Victoria, and the like applies to New South Wales.

CARBONIFEROUS GROUP.—Gold has been found disseminated in the Carboniferous sandstone of Springs Creek, 12 miles from Clermont, and in the conglomerate of Tallawang, Philip (New South Wales), but at Springs Creek mining proved unprofitable. Gold-finds have further been made in the argillaceous

shales and conglomerates of Peak Downs (Queensland), the Coal-measures of Shelley's Flat on the Shoalhaven River, and the conglomerate of Wingello (New South Wales), near Hobart (Tasmania), and also in New Zealand. Auriferous veins occur in Carboniferous deposits in the Gympie, Hodgkinson, Palmer and Crocodile (?) gold-fields (Queensland), in those of Swamp Oak, Niangala and Copeland (New South Wales), and in the Reefton and Lyell fields of New Zealand.

The so-called Gympie formation (greywackes, sandstones, conglomerates, slates and limestones, alternating with diabase sheets) is traversed by a great number of gold-bearing lodes, which can only be mined to profit where they cross the slates. Four zones of these latter have, so far, been explored, the upper one of which (Phœnix or Monkland slates) is about 2,000 feet thick. From the lodes of this zone the bulk of the Gympie gold is derived; the other three zones are less important. The lodes are chiefly composed of a whitish, milky quartz, with calcite here and there, in which visible free gold is irregularly distributed; very rich pockets are often found in disturbed parts of the veins, which will assay as high as 70 ounces of gold to the ton. Pyrite and galena also occur, but are poor in gold. The Monkland shaft is 1,600 feet deep.

The Crocodile field (Queensland) has but one auriferous repository of importance, that of the celebrated Mount Morgan. It is a gold-bearing mass of bluish grey quartz, siliceous hæmatite, manganiferous ironstone, white spongy or pumiceous siliceous-sinter, ochre and kaolin. From a depth of about 300 feet downwards, this decomposed gossany mass, or iron cap, passes gradually into pyritic ore, *i.e.*, into the pyritiferous quartzite on which it rests. The gold is very finely disseminated throughout, and rarely visible in spangles; the average content has gradually diminished in depth, from 5 ounces 16 dwts. 16 grains per ton in 1887 to 1 ounce 10 dwts. 23 grains in 1896. The annual tonnage is, at present, 95,000 with 147,000 ounces of gold. As to the genesis of this deposit (which is traversed by several dolerite, rhyolite and felsite veins), Dr. Schmeisser sides with Mr. T. A. Rickard, who considers it to be pyritiferous quartzite shattered and crushed by the intrusion of dykes, and then altered by the percolation of mineral solutions, the gold having being derived from the pyrites or, possibly, from the neighbouring auriferous sandstone.

The Carboniferous slates and sandstones of the New South Wales fields, above named, are traversed by many quartz-veins, which are only gold-bearing in the vicinity of diorite-dykes. In the Storm King mine, the ore averages 1 to 2 ounces of gold per ton, and assays sometimes over 16 ounces.

In the Reefton field of New Zealand, bedded quartz-veins occur in grey talcose-slate and sandstones of Carboniferous age. The gold is chiefly in a fine state of division, averaging $\frac{3}{4}$ ounce to the ton, and some veins carry considerable quantities of antimonite. Auriferous pyrite is frequent, galena rare. A few years back, several lodes pinched or wedged-out in depth, but one of them (in the Keep-it-dark mine) has since been followed down to a depth of 1,100 feet, where it stands now 16 feet wide, with $\frac{1}{2}$ ounce of gold per ton. The mines of this field have the advantage of good coal-seams, which are worked side by side with the gold-veins. Similar conditions obtain in the Lyell field, about 25 miles north of Reefton.

TRIASSIC.—Traces of gold are reported to have been discovered in the sandstone of the Hawkesbury beds at Govet's Leap and Togo Creek, north of Sydney, in the conglomerate of the Mittagong range and in the vicinity of Goulburn.

JURASSIC.—Auriferous rocks of this age occur near Fitzroy Downs and Peak Downs, Queensland, and some Mesozoic carboniferous shales of Victoria carry gold associated with pyrite.

CRETACEOUS.—In New South Wales, an ancient river-bed, filled with coarse gravel, which underlies the Cretaceous sandstone near Mount Browne, has been profitably mined for gold to a depth of 250 feet, but had to be abandoned on account of the water. Similar repositories have been found near Tibooburra and between Kayrunnera and Tarella. The Desert Sandstone of Queensland is also gold-bearing in places.

The so-called cements of Western Australia, which Dr. Schmeisser considers possibly of Mesozoic age, and which occur in the Kanowna, 25 Miles, East Murchison, and other districts, are described as auriferous sandstones, conglomerates, or breccias, composed of rounded or angular fragments of quartz embedded in a soft, clayey or talcose mineral of different colours. The thickness of the beds varies between 10 inches and 20 feet. They are probably derived from the weathering and decomposition of quartz-vein outcrops.

TERTIARY.—In the wider valleys of New South Wales, Victoria, South Australia, Tasmania, and New Zealand, and to some extent also in Queensland, ancient river-beds of Tertiary age are met with, the gravels of which, where derived from Palæozoic formations, have proved to be more or less gold-bearing. They are the so-called "deep leads" so often described, and which were mined long before the primary gold-repositories. These gravel-beds alternate repeatedly with sheets of basalt, and vary greatly in thickness from 3 to 350 feet, though the gold-bearing parts only range from 1 to 20 feet. Near the mouth of the Richmond river (New South Wales), a basalt cliff rises vertically out of the sea, and contains, near its base, a bed of basalt-slag or tuff which assays from 2½ to 18 dwts. of gold to the ton.

In the Hauraki gold-field, which embraces the Coromandel Peninsula of North Island (New Zealand), the Tertiary andesite and its congener the propylite are traversed by numerous quartz-veins, which are relatively strong and rich in gold in the propylite, but narrow and poor in the andesite.

Dr. Schmeisser's description of the Thames district does not differ materially from that of Dr. Park (*Papers and Reports relating to Minerals and Mining*, Wellington, 1894), whose coloured map and sections are reproduced in Plate IX., and as Mr. H. M. Cadell's comprehensive paper on Hauraki, with Dr. Park's map, has recently appeared in the *Transactions*,* we will only give Dr. Schmeisser's opinion as to the future of the field. He states that much depends upon whether the propylite can be proved to be an original rock, for if it is but a decomposed or altered andesite, it will, of course, at a lesser or greater depth, change into andesite in which the lodes pinch out or impoverish.

DILUVIUM AND ALLUVIUM.—Deposits of auriferous sands and gravels have been formed since Tertiary times in a great many of the gold-fields of Queensland, New South Wales, Victoria, Tasmania, and New Zealand, and have been worked to advantage. In Western Australia, the term "eluvial" for comparatively recent deposits is more appropriate, as they were for the most part evidently formed more or less *in situ*, that is near the outcrops of the lodes. The largest eluvial Western Australian nugget was found in 1890 in the Pilbarra field, and weighed 333 ounces.

For many years, and at different spots along the Australian coast, from Port Macquarie in New South Wales up to Queensland, a black, ferruginous sand, containing gold, platinum and tin, has been obtained at low tide, and is the result of the concentrating action of the surf on the sea-sands. The sounding-lead of H.M.S. *Herald* is reported to have brought up gold nuggets from the bottom of Port

* *Trans. Fed. Inst.*, vol. x., page 389.

Macquarie. Auriferous sands are also met with on the West Coast of New Zealand South Island, as well as on that of the Coromandel peninsula.

Dr. Schmeisser's last chapter treats of gold-winning in Australasia, and is a very summary account of its history, the laws which govern it, and of the mining and milling methods in vogue, which offers nothing particularly new to the readers of the *Transactions*. Having regard to the scarcity of water in the principal Western Australian gold-fields, Dr. Schmeisser is a decided partizan of the Krupp dry-milling process (presumably the Pape-Henneberg centrifugal concentration).

Some interesting data are brought together as to workmen and their wages, engineering and management of mines, cost of production, etc.; while the strictures on the all-pervading promoting, company-mongering, and stock-jobbing —though not by any means new reading—are, unfortunately, as welcome and to the point as ever.

General remarks on the statistics of Australasian gold-production introduce us to eight detailed tables concerning the production of the different colonies in 1894 or 1895, and Plate XIII. gives a graphic summary of the yearly production of each since gold was first mined.

Finally, as to the future of gold-mining in Australasia, Dr. Schmeisser points out that, as several mines of Bendigo and Queensland are raising good ore from depths of 2,000 to 3,000 feet, the opinion—which for some authorities is tantamount to an axiom—viz., that gold-veins impoverish in depth, is certainly untenable as a rule; although, on the other hand, it is undoubtedly borne out in numerous instances. He considers, further, that—apart from the many auriferous repositories already discovered, but which do not pay under existing local conditions, though a change in these might render them profitable—regions, more or less untrodden, still exist in the colonies where gold-bearing ground may be discovered in the future. All of which points to the conclusion that, for a long time to come, Australasia will continue to be a leading gold-producer. F. G.

THE MOROSCO FUSION-PROCESS FOR SULPHIDE-GOLD ORES.

ANON. *The Engineering and Mining Journal* [*New York*], 1896, *vol. lxi., page* 495, *and* 1 *illustration*.

A plant has been erected within the past year in the little mining town of Amador City which may have an important influence on the working of gold-bearing sulphide ores. The subjection of calcined ore to a molten lead bath, and extraction of the precious metals by so doing, is not an idea of recent date. To devise practical machinery for feeding the ore continuously into the lead; to then handle the same in its passage through the molten metal, so as to bring every particle of ore in contact with the lead for a sufficient length of time, to ensure perfect extraction of the precious metals; to discharge the tailings from the apparatus without any loss of lead; and to combine all these points successfully, has required much thought, labour, and capital.

The ore being reduced to 30 or 40 mesh is then roasted to burn off sulphur, etc. The roasted ore, while still at a high temperature, is at once fed into the bath-machine. The introduced ore must be considerably above the melting point of lead (640° Fahr.) in order that there may be no chilling effect upon the lead-bath.

The roasted ore is fed in a steady stream automatically to the bottom of the bath-well, which is a very heavy iron casting, 30 inches in diameter and 6 feet deep. The ore on reaching the bottom of this casting is freed, and at once attempts to rise by its own gravity through the bath of molten lead, of which there is over 5

tons. In this chamber are circular perforated plates, with reversed stir-arms between, and the ore is caught by the first stirrers and segregated, passing through the first plate and on to the second set of stirrers, and so on to the surface of the molten lead, where it is discharged automatically by a rapidly revolving disc, then to a trap-box of running water, which immediately chills the ore, and thence passes on to the concentrator. After the ore has passed through the bath it is said to carry no gold or silver, as the precious metals have become fused with the lead and are left behind in the well, while the ore as discharged into the water-box carries with it about 44 per cent. of lead, which is all recovered on the concentrators, re-melted and refined, and is used again in the bath. About 12 horse-power is required for running the machinery.

It is claimed that gold-bearing sulphides and base ores can be worked by this process for from 12s. to 16s. per ton, and yield over 90 per cent. extraction.

J. W.

ZINC *VERSUS* ELECTRICITY FOR CYANIDE GOLD-PRECIPITATION.

(1) *The Cyanide Process.* *By* JOHN YATES. *Proceedings of the Chemical and Metallurgical Society of South Africa*, 1894-1897, *vol. i., pages* 254 *to* 267.

The year 1895 witnessed the production of over 600,000 ounces of bullion by the cyanide process on the Rand; it is not surprising, therefore, that cyaniding should receive so much attention among those interested in gold-mining.

Two processes are now in use on the Rand for the precipitation of gold from cyanide solutions: first, the zinc process of Messrs. MacArthur and Forrest; and secondly, the electrical process introduced by Messrs. Siemens and Halske. The first-named gentlemen were the first to introduce zinc as a practicable precipitant, and they recommended the use of this metal in a fine thread, or shaving, such as is got by turning down thin discs of zinc in a lathe. Since 1890, when the cyanide process was first used on the Rand, the precipitant was without a rival; until, two years ago, when the Siemens-Halske electrical precipitation-process was introduced at the Worcester gold-mine, sheet lead being the cathode metal on which the gold is deposited as a film. The main feature in the plant for the latter process is the extra size of the extraction-boxes. The Worcester installation, having a capacity of 3,000 tons tailings per month, has four of these boxes, each 20 feet by 8 feet by 4 feet. The iron anodes are $\frac{1}{8}$ inch thick and 7 feet long by 3 feet wide. For the generation of the current, a dynamo requiring 5 horse-power is used.

To prevent short-circuiting, the anodes are covered with canvas, and the strongest cyanide-solution used on the tailings is only 0·1 per cent. The number and capacity of the leaching-vats have to be such as to permit of the tailings remaining longer under these solutions than is the case with ordinary zinc precipitation, where solutions as strong as 0·3 per cent. are used. The clean-up in the electrical process consists in taking the leaden sheets off their frames and replacing them by others; the auriferous sheets are melted down, cast into blocks, and then despatched to a central works for cupellation, the resulting bullion being finer than that yielded from zinc treatment.

A reduced size of box has been adopted in the newer plants, on the Siemens-Halske system, erected at the May Consolidated and Crown Reef mines. The Crown Reef has 4 boxes, 30 feet by 4 feet by 6 feet, each divided into 6 compartments. The labour required by the lead cathodes has been increased by using the lead in strips, instead of sheets as formerly. About 6 Siemens-Halske plants are now at work on the Rand. A plant at the Metropolitan mine, designed for very weak cyanide-

solutions and electrical precipitation, was run alongside of another plant on the zinc system for 11 months, when the electrical process was discarded, and now, cyanide solutions up to 0·4 per cent. are used. Mr. Yates appreciates the value of electric precipitation for slimes treatment, where excessively dilute solutions of cyanide are used: the strongest solution used for this purpose at the Crown Reef plant being 0·008 per cent.

The cost of treatment by each method is shown, per ton of tailings treated, in the following statements, where two plants are assumed, each of 500 tons per day capacity, of good and similar general design; the one plant being arranged for zinc precipitation with 4 days' treatment, and the other for electric precipitation with 6 days' treatment:—

MacArthur-Forrest Process, 500 Tons per Day Plant, Costs per Ton.

With Zinc Precipitation.	s.	d.
Filling and discharging	0	10·00
Cyanide of potassium, 0·7 lbs. at 1s. 1½d. per lb.	0	9·40
Lime and caustic soda	0	1·80
White labour	0	5·00
Native wages and food	0	1·90
Fuel and power (including haulage)	0	3·00
Zinc	0	0·75
Stores and general charges	0	2·75
Total cost per ton of tailings	2	10·60

With Electric Precipitation.	s.	d.
Filling and discharging	0	10·00
Cyanide of potassium, ¼ lb. at 1s. 1d. per lb.	0	3·40
Lime and caustic soda	0	1·70
White labour	0	5·00
Native wages and food	0	1·90
Fuel and power (including haulage and dynamo, and fractional maintenance and superintendence of generator and engine)	0	4·00
Lead	0	1·10
Iron	0	2·20
Stores and general charges (including cupellation)	0	3·20
Charge due to extra cost of plant (£5,000)	0	1·30
Loss of interest due to long retention of gold in extractor boxes	0	0·38
Total cost per ton of tailings	2	10·18

(2) *Zinc versus Electric Precipitation.* *By* A. von Gernet. *Ibid., pages* 281 *to* 292.

Replying to Mr. Yates' statement, that weak solutions of cyanide do not in practice always show a solvent efficiency equal to stronger ones, Mr. Von Gernet said though they might not always be, yet he thought that it was in general admitted that the solution of the gold depends much more upon mechanical conditions than upon the strength of the solution employed. Even 0·05 per cent. cyanide-solution, in contact with an equal weight of 5 dwt. tailings, contains more than 88 times the amount of potassium cyanide required. Should, under exceptional circumstances, gold take an extremely long time to dissolve in very weak solutions, a stronger solution would be employed. The amount of cyanide consumed depended mainly:—

1.—Upon decomposition during leaching of tailings, due to the chemical composition of the latter,—this increases with the strength of the solution, since more base metal is dissolved by the stronger, and, consequently, more cyanide is consumed.

2.—Upon decomposition during precipitation. This, with electrical precipitation, is equally small for strong and weak solutions; but, with the zinc process, increases with the strength of the solution used.

3.—Upon cyanide-solution lost by leakage, also as moisture in the residues. It is obvious, then, other things being equal, that in a 0·30 per cent. solution a larger amount of actual potassium cyanide has gone to waste than in a 0·05 per cent. solution.

Electric precipitation was not, of course, confined to weak solutions only, but might be used with equal effect on solutions of any strength.

Costs.—The author criticized some of Mr. Yates' comparisons of costs with plants of different dates; but, he accepted the figures given for electric precipitation, with a few alterations as follows:—

500 Tons Per Day Plant, Cost Per Ton with Electric Precipitation.

	s.	d.
Filling	0	10·0
Cyanide	0	3·4
Lime	0	0·5
White labour	0	5·0
Native labour	0	1·9
Fuel and power	0	4·0
Lead	0	1·5
Iron...	0	0·3
Charges due to extra cost of plant ...	0	0·5
Stores and general charges	0	3·2
Total cost per ton	2	6·3

It will be noted that the costs in the above estimate for iron, alkali, and extra cost of plant are lower than those given by Mr. Yates.

Slimes Treatment.—Here Mr. Yates admitted that the electric process was without a rival. The fact that ordinary low-grade slimes could now be profitably treated on a commercial scale was, as yet, hardly generally appreciated. For the first time in the history of gold metallurgy in the Transvaal had it been possible to treat all products of the ore: free gold, concentrates, tailings and slimes; and not only this, but the necessity which now hampers mining companies, of retaining as much pulp as possible in the tailings-vats at the risk of rendering the sands more or less slimy and unleachable, would disappear.

Early in 1897, slimes-plants capable of treating upwards of 50,000 tons monthly will be at work, and he predicted that, within a year's time, a slimes-plant would be considered just as necessary a complement to the mill as a tailings-plant.

J. W.

RELATIVE EFFICIENCIES OF STRONG AND WEAK CYANIDE-SOLUTIONS FOR DISSOLVING GOLD.

By W. A. Caldecott. *Proceedings of the Chemical and Metallurgical Society of South Africa*, 1894-1897, *vol. i., pages* 293 *to* 296.

The relation between the percentage of gold extracted and the strength of cyanide-solution used is a most important one, both from a scientific and practical point of view.

About a year ago, the writer made a series of experiments on a working scale to determine this question, from which it appeared that with little more than 3 days' treatment the same percentage of gold was extracted by a 0·052 per cent. potassium-cyanide solution as by a 4·334 per cent. solution from the tailings of a typical Rand Company. The explanation of the results might be found in a consideration of the conditions required to dissolve gold in cyanide-solutions. He thought that the fact of the efficient percentage strength of cyanide-solutions being limited by the amount of oxygen available had hardly yet been practically realized, and he trusted that his notes might serve to bring that point into greater prominence. J. W.

THE CYANIDE-PROCESS IN THE UNITED STATES.

By George A. Packard. *Transactions of the American Institute of Mining Engineers*, 1896, *vol. xxvi., pages* 709-721.

This paper gives tables showing the character of the ore treated by cyanide at a number of mills in the United States, and details of the treatment. The process had been applied there, on a large scale, only to rather low-grade, highly siliceous ores, containing but a small percentage of base metals, and having their value chiefly in gold.

An instance is quoted in which cyanide competed successfully with the smelters on ore carrying as high as 4 ounces in gold, the ore being one in which the value was easily extracted to a high percentage.

In the Cripple Creek district, where an extraction of 90 per cent. is obtained in from 4 to 6 days, and where the smelting-charges were from 20s. to 28s. per ton, ore running as high as £8 was in 1895 bought by the cyanide-mills. In the case of ores containing from 1 to 10 ounces of silver, in addition to a commercial gold value, the process has been advantageously employed. The Golden Reward Company, in South Dakota, having ores containing 1 to 5 ounces of silver, which was lost in chlorination, now treats such ores by cyanide. At this plant, early in 1895, they were using for chlorination about 35 lbs. of chemicals per ton of ore, while only $2\frac{1}{2}$ lbs. were necessary for treating 1 ton with cyanide.

The cost of cyaniding varies largely with the nature of the ore. There is a number of mills which crush and cyanide ore for less than 8s. 3d. a ton, exclusive of royalty paid to the company owning the patents. The lowest cost reported is 3s. 6d. a ton at the Mercur.

In the United States, nearly 200,000 tons of ore and tailings were treated by cyanide in 1895, producing over £200,000 in bullion-value. J. W.

THE ACTION OF CYANOGEN ON GOLD.

(1) *On the Position that Cyanogen holds in Relation to the Simple Radicals, and its Inability to Combine Directly with Silver or Gold. By* William Skey. *Transactions and Proceedings of the New Zealand Institute*, 1896, *vol. xxix., page* 574.

(2) *Further Results Showing that Free Cyanogen does not Dissolve or even Attack Gold. By* William Skey. *Transactions and Proceedings of the New Zealand Institute*, 1896, *vol. xxix., page* 576.

The author records the results of a series of careful experiments in which he shows that a solution of cyanogen gas has no solvent action, even upon extremely finely divided gold, provided that the cyanogen is pure, and that it is prevented

from decomposing, and more especially from forming alkaline cyanides, which are wellknown to dissolve gold. From these experiments the writer also infers that whilst cyanogen is at times monatomic like the compound radical carboxyl, it is on certain occasions diatomic like oxygen, and must not be grouped with the haloids.

[Note by the abstractor. – Aurous cyanide is insoluble in water; the above statements of Mr. Skey are of practical importance, seeing that the MacArthur-Forrest patents claim the use of cyanogen as a solvent for gold.] H. L.

THE FRASCH METHOD OF GOLD-EXTRACTION.

L'Exploitation Minière de l'Or au Transvaal. *By* ALFRED BOUDON. *La Revue Technique*, 1897, *vol. xviii., page* 172, *with diagrams.*

The author describes a new process devised by Mr. Hermann Frasch, and states that it has been employed in several of the Transvaal mines, but omits to give their names. The process is intended for alluvial deposits too poor to be worked in the ordinary way, but is applicable to other porous or permeable deposits of gold and analogous metals, such as silver and platinum. An aqueous solvent of the metal is to be forced or allowed to filter through the deposit, and the solution of gold or other metal thus obtained is drained off or pumped out, and the metal precipitated. The reagents to be employed are chlorine for gold (and platinum) and bromine for gold, alkaline hyposulphites for silver, and potassium cyanide for gold and silver. Numerous diagrams illustrate how the solutions are to be applied to and withdrawn from the metalliferous deposit. The solution of gold thus produced may be treated chemically or electrically. The author concludes by stating that great hopes are based on this new process. H. L.

THE COMBINED PAPE-HENNEBERG AND GOEPNER-DIEHL PROCESSES OF GOLD-EXTRACTION.

Das combinirte Goldextractions-Verfahren Pape-Henneberg und Goepner-Diehl im Vergleich zu anderen Verfahren. *By* C. BLÖMEKE. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 311, 328, *and* 367.

This process consists of a combination of the Pape-Henneberg system of dry dressing combined with the Goepner-Diehl process of cyanidation; it is especially adapted to gold-fields like Western Australia, where water is deficient. The following are the various operations:—

A. *Crushing.*—The ore is dried in a drying furnace, if it be moist when it comes from the mine. A system of gradual reduction is employed, the fine ore being taken out at each stage, and the ore is crushed successively in rock-breakers, rolls, or some other form of mill for medium crushing, and ball mills or rolls for fine crushing. The finest sieve has 25 to 30 holes to the inch. This process of gradual reduction prevents dead-crushing.

B. *Dressing.*—The plant consists of a prismatic or cylindrical vessel, a portion of the walls of which consists of wire-gauze; the interior of the vessel is connected to an exhaust-fan. The ore is allowed to drop in at the top, and under the influence of the lateral air-currents entering through the gauze the finer and lighter particles fall into divisions nearer the centre, the coarser and heavier nearest to the walls, whilst the finest particles are carried off by the air-current

and collected in a receiver provided with a dust-filter, so that all the crushed ore is recovered without any loss. Six grades of crushed ore are thus made, which are usually treated in three divisions.

C. *Extraction by the Goepner-Diehl Method.*—The solvent is a solution of pure potassium cyanide, to which a secret reagent is added ; the auriferous solution is separated by means of filter-presses ; to the solution excess of cuprous cyanide is added, and then sulphuric acid, which latter precipitates cuprous and aurous cyanide. After the precipitate has settled, the solution is syphoned off, and can be used again after neutralization by caustic soda and the addition of fresh potassium cyanide. The precipitate is re-dissolved in fresh auriferous solution, and re-precipitated by sulphuric acid, whereby a constant enrichment of the precipitate is produced. When sufficiently enriched, the precipitate is separated by means of a filter-press and dissolved in potassium cyanide ; gold is precipitated from the solution by electrolysis, cuprous cyanide being reproduced, and being thus capable of being used over again.

Experiments are quoted with Australian ores in lots up to 1 ton, which have given good results as regards extraction of gold. H. L.

THE ENGELHARDT BROMINE GOLD-EXTRACTION PROCESS IN OPERATION, U.S.A.

By D. C. Pret and H. Trachsler. *The Engineering and Mining Journal* [*New York*], 1896, *vol. lxii., page* 295, *and* 1 *ink-photo illustration.*

The so-called "refractory ores" of the La Plata Mountains, Colorado, which, when treated by amalgamation, yield an extremely low extraction, are found to vary in character to a great extent. Little development work has, so far, been done in the district ; but, during the last year four mines have been opened up and become regular shippers. Their product, principally tellurium-ore, has since been successfully treated at the bromination-works of Messrs. Pret, Trachsler & Company, at La Plata, Colorado, and the mines have produced enough ore to keep this plant in continuous work.

The ores in question are chiefly tellurium-ores similar to those of Cripple Creek. The gold is combined with tellurium as sylvanite and petzite ; in some veins as hessite, the greater part of the gold being replaced by silver. Free gold is only found in the more decomposed ore-bodies near the surface, and those mine-owners who erected stamp-mills have had to suspend operations. After a close investigation upon the most suitable treatment of these ores, the authors came to the conclusion that they had to select one of the three known wet processes : Cyanide, chlorination, or bromination.

The cyanide and chlorination-processes, after experiments, were deemed unsuitable, and the bromination-process was adopted for the following reasons :—First, the solvent power of muriatic acid solution of bromine, in the barrel especially, with the addition of soda-ash or any other cheap carbonic-acid producing alkali, or alkaline earth, is greater than that of chlorine-solutions, the action being also more uniform and quicker, and, therefore, the extraction of gold generally higher. Second, owing to the small amount of bromine used per ton of ore, the freight on chemicals is considerably less than the cost of chemicals used in chlorination. Third, the way of applying the bromine in the barrel takes less time, and the charging of the same is less injurious to the operator.

The analysis of an average sample of La Plata ore, taken from a 100 tons lot, gave:- Silica, 80·5 per cent.; iron sesquioxide, 10·0 per cent.; lime, 1·05 per cent.; magnesia, none; alumina, 3·7 per cent.; sulphur, 2·80 per cent.; total, 98·05 per cent. The remainder of 1·95 per cent. is made up by small quantities of copper, arsenic, chromium, titanium and tellurium, which are easily detected in solutions after treatment. The values in silver and gold of different shipments were found to be from 1·25 ounces to 2 ounces in gold and from 0·5 ounce to 1 ounce in silver per ton. The greater part of the gold is found combined with tellurium, and probably as sulphide of gold in the arsenical iron pyrites.

The Bruckner furnace is used, and a perfect dead roast is got in 8 hours. The roasted ore is elevated from the cooling-floor and charged into a lead-lined revolving barrel with water and the necessary amount of chemicals. The strength of solution employed is on an average 0·25 per cent.; but they found that a 0·15 per cent. solution, equal to $1\frac{1}{4}$ lbs. of bromine per ton of ore, can be used to advantage. The extraction of the gold takes place in 2 to 3 hours.

The leaching from the barrel takes place in 35 to 45 minutes, even on slimy charges containing quantities of flue-dust. The solutions being free of slimes and perfectly clear, do not require any settling; this is considered a great advantage over the use of barrel-chlorination, where the slimes of sulphate of lime, from "bleach" and sulphuric acid, require from 12 to 24 hours' settling. Thus, much time is saved, and the capacity of the works is materially increased by the use of bromine.

The bromide of gold is decomposed by hydrogen sulphide, the small excess of free bromine being first eliminated by a stream of sulphurous acid and compressed air. The elimination of the free bromine and precipitation of the gold take from 15 to 25 minutes per tank of 3,500 gallons of gold solution The precipitate is settled in the tanks for 2 to 3 hours and the supernatant liquor drawn off, running through a Johnson filter-press. At the "clean-up," the precipitate is refined as in barrel-chlorination. The average extraction on ores pulverized to 16 mesh varied from 93 to 96 per cent. J. W.

THE GRAPHITE-DEPOSITS OF NORTHERN MORAVIA.

Die Graphitablagerung bei Mährisch-Altstadt—Goldenstein. By Franz Kretschmer. *Jahrbuch der k. k. geologischen Reichsanstalt, 1897, vol. xlvii., pages 21 to 56, with a figure in the text and Plate I. (map), Vienna.*

These deposits occur in Archæan crystalline limestones, which are interbedded with amphibolites and schistose muscovite-gneiss. The limestone is granular, varying in colour from grey to greyish-blue and black, by reason of the intermixture with it of graphite-scales. It is seamed by thin bands of dark green serpentine, which is in places decomposed to steatite. Here and there, the whole mass of the limestone is impregnated with serpentine. The limestone forming the floor of the seams is white to light grey in colour, coarse-grained, marmorized, and massive. The limestone forming the roof is finer in grain, darker in colour, and more thinly bedded. The map shows that these graphite-bearing limestones form a mere ring some 300 to 450 feet broad round a central core of gneisses and amphibolites, the latter rocks being repeated outside the ring. The longitudinal section shows that the Sattel graphite-seam forms the two limbs of an anticlinal, while the Baderberg and Vorwerk seams each form one limb of a small synclinal.

The graphite is iron-black, greasy to the touch, has a strong metallic lustre, and occurs in small scales or schistose aggregates of large flakes, and is impregnated with finely divided iron pyrites. Other impurities are white quartz and calcspar, dark limestone, brown iron ore, and strongly kaolinized gneiss. The mineral passes in some places into a hard schistose mass forming a true graphite schist. The average percentage composition, deduced from a long series of chemical analyses, is :—

Carbon	53
Ash	44
Water (loss on ignition)	3
	100

The ash is largely made up of silica and iron oxide, with very little alumina, magnesia, sulphur, etc. This graphite is the richest in carbon of any in Moravia, and most of the pyrites is easily got rid of in the preliminary sorting (in the wet way).

The lowest seam is the Sattel, forming, as before stated, the limbs of an anticlinal with outward dips of 20 to 40 degrees. It varies in thickness from an inch or two to 8 feet, but, taking into account the frequency of "horses" and "riders," the average workable thickness of pure mineral hardly exceeds 5 feet. Completely or nearly barren areas occur for the most part at those points where, instead of limestone, the schistose, highly weathered, rusty gneiss forms the roof.

Next above comes the Baderberg seam, called after the hill where it is worked. It is much more profitable than the Sattel, ranging from 10 to 20 feet in thickness, the average workable thickness of pure mineral being 8 feet or more.

The uppermost seam is the Vorwerk, and, although it shows a great thickness of graphitic rock, the thickness of workable graphite does not exceed 5 feet. Here and there are lenticles 20 feet thick. The Vorwerk graphite is mostly soft, but there is much hard stuff too which passes, deep down, into graphite-schist. Iron pyrites and porous brown iron ore are abundant - the latter probably a decomposition-product of the former. The presence of ferrous sulphate crystallized in little plates and granules is also noted.

So far as quality is concerned, the Sattel seam takes the first place, consisting almost entirely of soft flaky graphite, with but a few bands of hard mineral. In the Baderberg seam, there is a greater proportion of hard graphite, and in the Vorwerk seam still more.

The author regards the graphite as the highly metamorphosed representative of beds of vegetable detritus, dating from the oldest geological period known. Its present condition is the result, firstly, of contact-metamorphism induced by the amphibolites ; and, secondly, of the thrust-movements which ridged up into folds the rocks wherein lies the graphite. The seams themselves show the effects of enormous pressure, being in many places crushed and folded.

Detailed descriptions are given of the method of working and the plant employed, together with descriptive vertical sections of the mines. The graphite is washed on the spot, and, packed in barrels according to quality, finds a ready sale in Hungary, Germany, and England. The total annual production of raw mineral averages 45,384 cwts., and of "refined" mineral 28,612 cwts.

Magnetite is worked on the roof of the Sattel seam at one point. It contains 42·18 per cent. of metallic iron. Antimony glance is got from a vein in serpentine-impregnated limestone, where it is associated with mispickel, zinc-blende, galena, etc. ; but it does not pay to work at the present price of antimony. L. L. B.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

BOILER ACCIDENTS IN FRANCE IN 1896.

Bulletin des Accidents d'Appareils a Vapeur survenus pendant l'Année, 1896. *Résumé résultant de l'Étude des Dossiers administratifs.* OFFICIAL REPORT. *Annales des Mines*, 1897, *series* 9, *vol. xii.*, *pages* 638-657, *and* 3 *plates.*

Of the 44 accidents recorded in this paper, resulting in the loss of 16 lives and in serious injury to 25 persons, only 1 took place at a colliery, and in that case the firemen had time to seek safety in flight. The colliery was that of Portes, in the Gard coal-field. The boiler was horizontal, non-tubular; its hinder end rested on the masonry of the furnace, which was damp, on account of long-continued leakage from the waste-cock. The acid fumes arising from the combustion of pyritous coal had set up deep corrosion of the plates in contact with the damp masonry. The apparatus had been built in 1874, but had been used as a steam-boiler only since 1886.

At the steel-works of St. Martin (Meurthe-et-Moselle), a vertical cylindrical boiler with field tubes, working a steam-crane, tore open and went up like a rocket. No one was hurt, and the actual cause of the accident has not been thoroughly elucidated. There was a similar absence of injury to persons and a similar default of assignable cause in the case of the Naeyer boiler at the blast-furnaces of Marnaval (Haute Marne). In this boiler, built in 1889, one of the steam tubes, about 4 inches in diameter, suddenly split open for a length of 13 inches, just as the boiler had started working.

With regard to the other 40 accidents, 21 occurred in various factories, 9 in electric lighting works, 5 on railroads and tramways, and 5 on shipboard. Of the whole number, 15 took place in water-tube boilers, and precisely the same number of accidents was due to overheating. In 14 cases, it was found that the boilers had not been kept in proper repair, and in 18 cases that they were of bad build or material, or badly rivetted. L. L. B.

ECONOMY AFFORDED BY ARTIFICIAL FURNACE-DRAUGHT.

Le Tirage artificiel des Foyers. *By* M. KESTNER. *Bulletin de la Société du Nord de la France*, 1897, *vol. xxv.*, *pages* 399 *and* 403.

The interesting subject of mechanical furnace-draught is still but little understood, and the natural draught of the chimney is that generally employed. This, however, often causes a loss amounting to 25 per cent., and sometimes to 35 per cent., of the available heat. If the work be calculated that is required to take off the products of combustion by the chimney, it will be found that 5·6 ounces (160 grammes) of coal only produce 0·004 horse-power, the useful effect being almost *nil*; but, on the other hand, mechanical draught has the same efficiency as that

possessed by the fan, which is at least 33 per cent. Moreover, the fan affords a more regular working, being independent of the weather and change of wind; and the draught can be increased or diminished at will, while the heating surface may be greatly increased without fear of putting out the fires. Artificial draught comprises both forced and induced draught, and trials show that the latter method is the more economical. When a chimney is found insufficient to afford the required draught it is often supplemented by mechanical means. For forced draught, a steam-jet is sometimes used for driving in the air necessary for combustion; and this method has some advantage connected with the utilization of poor fuels, although it is costly, consuming from 8 to 10 per cent. of the steam generated by the boilers, compared with which induced draught absorbs less than 1 per cent. of the boiler-power. The author concludes that, from every point of view, artificial is to be preferred to natural draught. J. W. P.

FUEL SAVING AT THE SAAR COLLIERIES.

Versuchsergebnisse im Dampfkesselbetriebe auf den Gruben des Saarreviers. By Berginspektor Osterkamp. *Glückauf*, 1897, *vol. xxxiii., pages* 398-400.

Even if the coal consumption of collieries does not entail so great expense as in other branches of industry, especially in districts far removed from a colliery, waste of fuel is not justified, when it may be prevented by the simple means here recorded, that are employed at the Prussian state collieries in the Saar district.

In front of each fire-door of ordinary two-flued boilers, a vertical draw-rod, provided with a handle, passes through an angle-iron fastened above the door-frame, and also through a bearing-block fixed to the top of the setting; and a cord from each draw-rod passes over two pulleys attached to the front of the setting, a third pulley being fixed in the vertical plane of the damper. The two cords, united in one, pass over the back pulley, being attached to the middle of the damper, which is balanced by adjustable counterweights. As a rule, the draw-rod handle comes about the middle of the closed fire-door; and for opening the latter the stoker must push the rod above its upper edge, thus closing the damper to within 2 inches (50 millimetres), a space which must be left open so as to prevent the flame from being driven back out of the flue. The cost of this arrangement, which can easily be applied to any boiler, is insignificant in comparison with the advantage it affords of preventing more than a very little coal from remaining unburnt.

Nearly every boiler setting at the Prussian state collieries is arranged with flues in the manner now to be described; and it is found that, with this method of leading off the products of combustion, the boiler-plates are heated with sufficient regularity while irregular expansion is prevented, and pitting and furrowing at the seams is completely obviated. Under the supposition that there is an upper flue in the usual two-flued boiler, the products of combustion, after being drawn through the flue tubes, pass into the lower flue, licking the whole under surface of the boiler, and pass at the front end thereof through two vertical rectangular flues (one on each side of the boiler) into the upper flue, that is over the steam space, and up the chimney. In the narrowest part of each vertical rectangular flue there is an iron flap-valve turning on a horizontal axis. On the end of each spindle (passing through a tight stuffing-box) that projects beyond the front plate of the boiler is keyed a short lever, which actuates a vertical movable rod directed downwards; and this rod hangs with its lower end in a second lever, which is connected with a horizontal shaft under the fire-door. Turning this shaft, which rests on the

edge of the projecting fire-plate, will necessarily communicate motion to the two dampers. The shaft, fitted with a bevel spur-wheel, is rotated by the bevel spur-pinion on an axle which, with a feather, passes through the fire-door hinge. The boss of the bevel-wheel, that turns loosely on the shaft, is provided with a carrier; and the action of turning the wheel pushes the carrier against a corresponding tooth of a set-ring keyed fast on the shaft. When the fire-doors are closed, the dampers, in a vertical position, permit the products of combustion to pass off freely; but, when one of the fire-doors is opened, its turning movement is communicated, through the pin, the bevel-wheel, and the set-ring, to the shaft, without, however, acting on the other fire-door. The shaft brings the two dampers to a more or less horizontal position, the draw-rod being arranged in the best position for each boiler; and the same action is similarly effected by opening the other fire-door. On closing the doors, it is only the bevel-wheels that are moved with any degree of force, the dampers at the same time falling round their axes, leaving the sectional areas of the flues again free.

Up to the present time, with 500 boilers set in this manner since 1884, no case has occurred of leakage in the under portion of the circular seams in the boiler-shell, whereas in those set according to the former method, without an upper flue, such leakages often led to inconvenient interruption in working.

Trials with two similar boilers, set in the two manners, showed that 1 pound of coal evaporated 7·04 pounds of water in the boiler with an upper flue, against 5·93 pounds for that without it, effecting a coal-saving of 6 cwts. (300 kilogrammes) in 24 hours. The boiler with an upper flue also showed a greater degree of vaporization, while with forced draught the advantages would be even more marked, so that 100 tons of coal might be saved for each boiler per annum.

J. W. P.

STRAIGHTENING TWO MINE CHIMNEYS.

Note sur le Redressement de deux Cheminées exécuté par la Compagnie des Houillères de Saint-Etienne. *By* — PERRIN. *Comptes rendus mensuels de la Société de l'Industrie minérale*, 1898, *pages* 44-47, *and* 3 *plates*.

The two chimneys in question had not become crooked, but had simply lost their verticality, and this to such an extent that serious thoughts were entertained of rebuilding them, although fortunately they were both restored to their normal position at a far lower cost, and without any accident.

The chimney, 105 feet (32 metres) high, serving the boilers of the Saint-Louis pit showed an overhang of 4 feet 3 inches (1·315 metres) on the southern side, and of 2 feet $1\frac{1}{2}$ inches (0·655 metre) on the western side, so that it was necessary to make a cut of $4\frac{9}{10}$ inches (0·116 metre) at the northern angle, and of $2\frac{1}{4}$ inches (0·057 metre) at the eastern angle. Inasmuch as winding could not be interrupted and the engines exhausted into the base of the chimney, all the work of straightening had to be effected from the outside of a mass weighing about 300 tons. The section of brickwork was divided into nine imaginary squares of the same size as the central space; and two shifts of four men each worked simultaneously at two of the squares, making cuts $6\frac{1}{2}$ inches (from 16 to 17 centimetres) high, and placing therein pairs of oak wedges, previously greased with tallow, placed in the proper situations, head to point alternately, and driven with sledge hammers until they would go no farther. Further cuts were then made in two other squares, and of as slight thickness as possible, simply for effecting a separation between the two parts of brickwork, and with only one wedge each, at the further necessary points,

after which cuts were made successively in the remaining squares. These last cuts would have permitted the air to enter the chimney, so as to interfere with the draught, were it not that a packing of fire-clay, kept constantly wet, was introduced into the cuts for surrounding the inside space of the chimney. When the weight was supported entirely by wedges, straight-edges provided with plumb-lines were fitted to the outer sides of the chimney. Recesses were then made for receiving four powerful screw-jacks at the necessary points; and the operation of restoring the verticality was begun. While one man worked the jack, others struck alternately on the upper wedges in such a manner as to drive them out, while the tension of the jack was constantly maintained; and the work was continued, wedge by wedge, until the plumb-lines showed that verticality was restored. In some cases the wedges could not be moved, so they were cut out by chisels, and replaced by others freshly greased, this operation entailing no danger on account of the large number of points supported. It now only remained to carefully clean out the various squares cut into, and to fill up with brick and cement the space that remained while cutting out the last wedges that still sustained the load. The whole work occupied eight men for 9½ days; and the total cost, including materials, was £29 18s. 6d. (748 francs 10 centimes), compared with which a new chimney would have cost nearly £400 (10,000 francs).

The other chimney, estimated to weigh nearly 500 tons, served not only for the coke-ovens, but also for the boilers of the Verpilleux shaft which it was necessary to keep going; and the work of straightening could not be performed, as in the other case, entirely from the outside, because the chimney is lined with firebricks, between which and the chimney proper, of ordinary brick, is a space 2 inches (5 centimetres) wide which had to be preserved. Accordingly, a temporary chimney was made from an old boiler. Plumb-lines showed an overhang of 4 feet 1 inch (1·25 metres) on one side, and 2 feet (0·6 metre) on the other, so that it was necessary to make cuts of 7 inches (18 centimetres) on one side, and of 3½ inches (9 centimetres) to 7 inches (18 centimetres) on two others. The incisions were made and the wedging effected in the same manner as in the case above-mentioned, except that the firebrick lining was cut into from the inside. The straightening of the chimney by screw-jacks alone occupied 16 hours, because it could only be effected with great care, both for preserving the structure and for protecting the men. The whole operation was, however, successfully accomplished in 12 days, at a total cost of £37 6s. 10d. (933 francs 45 centimes). J. W. P.

ULTIMATE ANALYSIS OF COAL.

Ueber Elementaranalyse von Kohlen. By F. Haber and S. Grinberg. *Zeitschrift für Analytische Chemie*, 1897, *vol. xxxvi.*, *pages* 557-567.

In the method employed by the authors, and which is claimed to overcome the defects and inconveniences attendant on other methods in use, the coal (½ gramme) is burned in a platinum boat inserted in a combustion tube, 17 inches (43 centimetres) in length, containing a 2½ inches (6 centimetres) layer of lead chromate and 1 gramme of 10 to 20 per cent. platinized asbestos, kept in place by a plug of copper oxide. The tube is protected externally by a trough of copper-gauze of about 400 meshes to the square inch, and is heated by two Teclu burners, the boat containing the coal being pushed forward (by means of a hooked copper wire passing through the stopper of the tube) to the part of the tube opposite the wire-gauze, and then left in order to allow the moisture

to evaporate, after which it is again moved ½ inch further. Volatilization now begins, and when terminated, the coal is once more pushed forward repeatedly as the glow in the mass disappears. Finally, when it reaches the copper oxide plug the platinum boat is exposed to the full heat of the large burner until the combustion of the coal is complete. The oxygen current admitted throughout the whole operation is regulated so as to keep the coal burning with a red flame—two or three bubbles per second being sufficient. The analysis usually occupies 45 to 60 minutes, four or five forward movements of the coal being made, at 10 minutes' intervals, in order to regulate the evolution of gas. A number of analyses of different classes of coal are given to show the uniformly correct results yielded by the method. The error in the carbon dioxide estimation, caused by the absorption of nitro-acids in the caustic-potash apparatus, lies between 0·02 and 0·18 per cent.; but as this error is equivalent to only 16 units of heat (taking the Dulong equivalent, 1 per cent. of coal equals 80 calories) it is within the ordinary range of experimental error. The same applies to the slight trace of error (0·025 per cent.) in the hydrogen determination.

C. S.

RELATION BETWEEN THE COMPOSITION AND FUSIBILITY OF COAL-ASH.

Sur les Relations entre la Composition et la Fusibilité des Cendres de Houille. By Eug. Prost. *Bulletin de l'Association Belge des Chimistes*, 1897, xi., page 119.

The author gives in tabular form the principal constituents of six samples of coal-ash, which he compares with those of twenty-three samples that he had examined previously, and he arrives at the following conclusions:—

The fusibility of coal-ash is greater in proportion as the proportion of flux, *i.e.*, the iron oxide, lime, and magnesia is more, and, consequently, the content of alumina silicate is less. Although coal-ash practically contains the same constituents as the clays, its degree of fusibility cannot be deduced from its composition with the same exactitude as for the latter. If it be considered that, for one and the same flux-content, it is sometimes the iron oxide and sometimes the lime which predominates, *i.e.*, bases whose fusing action is different, a very regular scale of fusibility cannot well be hoped for; at the same time, it might be useful for practical purposes to establish for coal-ash a "quotient of resistance to fire," even if only approximate, as a function of the silica, alumina, iron oxide, lime and magnesia contents.

Taking, by way of example, a coal-ash containing SiO_2, 49·46 (equal to 26·37 of oxygen); Al_2O_3, 33·28 (15·66 oxygen); Fe_2O_3, 5·50 (1·65 O); CaO, 2·76 (0·78 O) and MgO, 0·78 (0·32 O); if the oxygen content, S, of the silica be divided by the oxygen content, A, of the alumina, we shall have the ratio:—

$$\frac{26{\cdot}37}{15{\cdot}66} = 1{\cdot}68; \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and if, on the other hand, the oxygen, A, of the alumina be divided by the sum, B, of the oxygen in the other bases (Fe_2O_3, CaO, MgO) we shall obtain—

$$\frac{A}{B} = \frac{15{\cdot}66}{2{\cdot}75} = 5{\cdot}69; \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and next, dividing (2) by (1), we obtain—

$$Q = \frac{5{\cdot}69}{1{\cdot}68} = 3{\cdot}39. \quad . \quad . \quad . \quad . \quad . \quad (3)$$

So long as the flux contents do not exceed certain limits, this last quotient may serve to measure the fusibility of coal-ash, the ash being less fusible in proportion as the quotient is high.

Applying this formula to twenty-nine samples of coal-ash, the compositions of which are given by the author, he found a series of values which bear a sufficiently regular relation to the degree of fusibility possessed by the samples of ash to which they refer.

A knowledge of the degree of fusibility possessed by coal-ash is in some cases of great importance to the coal-user, as the ash of coal for firing marine boilers should stand very high temperatures without forming clinker, which, adhering to the furnace-bars, prevents the admission of air. In practice, coal-ash may be divided into three classes:—(*a*) That which remains refractory at a temperature of about 2,700° Fahr. (1,500° Cent.); (*b*) that which is fusible between that temperature and about 2,400° Fahr. (1,350° Cent.); and (*c*) that which is fusible at a temperature lower than 2,400° Fahr. (1,350° Cent.). It may be considered that the first class comprizes those for which the above-named quotient attains or exceeds 2·25, provided the iron-oxide content does not exceed 7 per cent.; the second, those in which the value of the quotient descends to about 1·6 (it may, however, attain and even exceed 2·25, though in that case the proportion of iron oxide is considerably higher than 7 per cent.); and lastly, all matters which show a quotient below 1·6 cannot withstand a temperature of about 2,400° Fahr. (1,350° Cent.). J. W. P.

REGULATIONS AS TO DAMPING OF COAL-DUST IN FIERY MINES IN DORTMUND, GERMANY.

Bergpolizeiverordnung betreffend die Befeuchtung des Kohlenstaubs in Schlagwettergruben. Official Regulations. *Königliches Oberbergamt Dortmund, July 12th*, 1898.

In all fiery mines sprinkling arrangements must be laid down and kept in good order for damping all the workings, in order to prevent danger from coal-dust. Where such arrangements have not already been provided, or have not been prescribed by special ordinance, they must be completed by July 1st, 1899, in bituminous seams, and by January 1st, 1900, in all other cases, damping being effected by other sufficient means during the interval. Exemption may, however, be granted, for the whole or part of a mine, when the workings are naturally damp, or there appears no reason to fear the production of coal-dust.

In all workings for exploring, opening out and coal-getting, for which the sprinkling arrangements are enjoined, the roof and sides and also the coal got must be made sufficiently damp to prevent a layer of dry coal-dust from forming upon them; and those ways which serve for haulage, travelling or ventilation (as also inclines) must be so damped that any coal-dust settling in them is rendered harmless. Exemptions, however, may be granted for those workings, where it can be proved that the roof and floor might be weakened by damping and increase the danger from falls.

The workmen in charge are responsible for the damping of workings, for exploring, opening out and coal-getting to a distance of 66 feet (20 metres) from the face; and that of roads, airways and inclines must be effected by a sufficient number of trustworthy men specially appointed, who must be served with written instructions as to their duties, which, with their names, must be entered in the mine journal.

The workmen thus appointed must at once notify the district overman or his representative should they be prevented from performing their duties by any deficiency in or deterioration of the damping arrangements; and the above-named officials must take care that the men entrusted with the damping duly carry out their duties, and also that any deficiency in or deterioration of the arrangements be at once remedied. When, however, this is impossible, all work for getting coal must be suspended at the points in question. In addition, the underground manager *(betriebsführer)* is responsible for the erection and keeping in order of the damping arrangements, as well as for their being properly used.

Infractions of these regulations are subject to a fine not exceeding £15 (300 marks), if a more severe penalty be not provided by the common law.

J. W. P.

MANUFACTURE OF COKE FROM PEAT.

Ueber Torfverkohlung. Dr. Holtz. *Zeitschrift für angewandte Chemie*, 1897, *pages* 772-776.

At Oldenburg, peat (cut by Dolberg turf-cutters from a large moss adjacent to the Hunte-Ems canal) is converted into coke by the Ziegler-Stiemer process, the retorts used being similar to those employed in the distillation of brown-coal, *i.e.*, vertical cylinders about 26 feet (8 metres) in height, and 80 inches (2 metres) in internal diameter, the lower two-thirds being formed of glazed firebrick and the remainder of cast-iron rings, space being afforded about half-way up for the discharge of the gaseous products. The dried peat is fed through the top, and the glowing coke drawn off at the bottom into a chamber where it is quenched by a steam-jet. A light or a heavy coke is obtained according to the quality of the peat and the heat of the retort, a high temperature favouring the production of a dense coke resembling that from ordinary coal. When mixed with saltpetre, the light coke replaces charcoal briquettes, whilst the heavier quality is used in copper-works and blast-furnaces, for which purposes it is well adapted, being free from sulphur and phosphorus, burning quietly, and giving out about 7,000 units of heat.

The vapours liberated in the still are condensed, the permanent gases being employed to heat the furnaces. The tar is re-distilled and yields benzine, a heavy gas oil and a solid product, furnishing paraffin scale, and lubricating oil, the residue varying from a viscous pitch to hard carbon suitable for the manufacture of arc-lamp pencils. Calcium acetate and ammonium sulphate are recovered from the tar-water. From 8 to 10 tons of peat can be coked in each retort *per diem*, furnishing 36 per cent. of coke, 3 per cent. of tar, 20 per cent. of tar-water, 21 per cent. of moisture, and 20 per cent. of gas; the tar-water yielding 44 pounds (20 kilogrammes) of ammonium sulphate, 66 pounds (30 kilogrammes) of calcium acetate, and about 22 pounds (unrecovered) of methyl alcohol per 220 gallons (1 cubic metre).

C. S.

ARTIFICIAL DIAMONDS.

Sulla Riproduzione del Diamante. *By* Q. Majorana. *Rivista di Mineralogia e Cristallografia Italiana*, 1898, *vol. xix., pages* 22-29, *with figures in text.*

The author points out that, in the main, the Moissan method of transforming carbon or graphite into diamond consisted in applying enormous pressure and excessive heat to a lump of carbon. Noting, by the way, that the various kinds of amorphous carbon have a specific gravity of less than 2, while the specific gravity of graphite is 2·5 and that of diamond 3·5, we are reminded that

amorphous carbon is rendered plastic by great heat; thus, if one of the carbon rods used in an arc-lamp be heated to brilliant whiteness (by means of an electric current of high intensity), the application of a very small force will suffice to bend it. From this may be deduced the possibility of exercising such a pressure on carbon thus softened, as to make it pass from a specific gravity of 2 to a specific gravity of 3·5, and thus to produce diamonds. The foregoing deduction was verified experimentally by Prof. Moissan, but his method conveys the impression that the solubility of the carbon in the subsequently cooled metal is essential. The author proceeded on Prof. Moissan's lines, but by a more direct process. He used as his source of heat the electric arc, and explosives as his source of pressure.

The apparatus devised for the purpose is described and figured. It consisted essentially of a hollow cylinder of untempered steel, strengthened by a succession of iron hoops about ½ inch thick. A piston closes one end of the chamber; to it is attached a rod of tempered steel, upon which is fixed a lump of carbon weighing about 31 grains (2 grammes). The apparatus is made up of a large number of parts, as it is found that this form of construction is the only one which obviates the risk of rupture or deformation; it is calculated to stand a pressure of about 5,000 atmospheres.

The lump of carbon is brought to incandescence by a double electric arc, the lump itself forming the central conductor. The current used is of 100 volts, 25 ampères, and the carbon (the same as that composing arc-lamp rods) is heated to a temperature of 5,400° to 7,200° Fahr. (3,000° or 4,000° Cent.); after 15 or 20 seconds the fine-grained gunpowder (2½ ounces or 70 grammes) placed in the chamber beyond the piston is ignited by electricity, and as it explodes the carbon is jammed into a cavity prepared for it in the centre of a steel block, which is exactly below the piston.

The result was a mass of amorphous carbon, graphite, and impurities, from which, by treatment with acids, graphite and diamond were separated. The density, hardness, crystalline structure, and invulnerability to acids left no doubt as to the character of the diamond-particles obtained; it was shown that these scratched a well-polished surface of ruby. The author figures some of them magnified 300 times; some were completely opaque, others quite transparent.

Instead of the carbon used, which necessarily contained impurities, the author was wishful to make use of pure carbon got from sugar, but this crumbled up every time as soon as it was subjected to the action of the electric arc.

L. L. B.

DIAMANTIFEROUS ROCKS OF SOUTH AFRICA.

Note sur les Minéraux et les Roches du Gisement diamantifères de Monastery (Etat libre d'Orange) et sur ceux du Griqualand. By A. Lacroix. *Bulletin de la Société Française de Minéralogie*, 1898, *vol. xxi., pages* 21-29.

The author describes, in the first place, the samples recently brought back by Mr. A. Reitlinger, from the Monastery Farm (Orange Free State), about 30 miles south of Winburg, and 140 miles distant from the great Jagersfontein diamond-mine.

The surface-area of the diamantiferous chimney is not particularly well defined: it may be anything from 5 to 12 acres. The rich conglomerate or blue ground is struck at a depth of 81 feet, and traces of old workings have been found as far down as the 50 feet level. The blue ground is, in structure, exactly similar to that of Griqualand. The minerals (1) and rock-pebbles (2) which make it up are:

(1) pyrope-garnet, diopside, ilmenite, zircon, biotite, apophyllite; also a fine sand made up of these and of minute fragments of olivine, enstatite, biotite, magnetite, chromite, etc.; (2) labradorites, diabases, peridotites and kimberlite.

The author describes the minerals, mentioning especially the pyrope-garnets, or so-called "Cape rubies"—identical with those found at Kimberley; one-half of a rounded crystal weighed no less than $3\frac{3}{4}$ lbs., but usually the garnet occurs in grains of the size of a pea. The diopside and ilmenite often form together a sort of graphic-pegmatite; there is little doubt that both of these minerals come from the kimberlite, whereas the garnet is a product of the peridotites.

Turning now to the rocks, the labradorites and diabases are fine-grained, with ophitic structure, more or less rich in olivine, and resemble those which are abundant at Kimberley.

The kimberlite is less decomposed than that described by Mr. Carvill Lewis from Griqualand. It is a rock rich in mica, and was evidently consolidated in two phases. Olivine, garnet, enstatite, diopside and ilmenite-phenocrysts are abundantly distributed in a brownish, serpentinized, vitreous magma containing very pale yellow biotite-flakes, grains and crystals of ilmenite, perouskite, chromite and magnetite, also altered nepheline; the rock is impregnated with secondary calcite, and is the chief infilling-material of the diamantiferous chimneys. Mr. Carvill Lewis believed that he discerned in it microscopic diamonds, though he could not isolate them; but the present author has been able to prove the existence of an octahedral crystal of diamond, associated with grains of garnet, on a lump of kimberlite brought from the Du Toit's pan. Nevertheless, he does not believe that kimberlite is the only, or even the chief, matrix of the diamond—a conclusion, indeed, which it would be hazardous to draw from the single occurrence just mentioned. The solution of the problem may be found in the peridotites. These show a granitoid association of enstatite and olivine, with such accessory minerals as induce the author to classify them as harzburgites. In these occur the rounded garnets, which are also found loose in the blue ground, showing that their rounded form is not of secondary origin.

L. L. B.

RECENT BAVARIAN EARTHQUAKES.

Ueber die in den letzten Jahren in Bayern wahrgenommenen Erdbeben. By C. W. VON GÜMBEL. *Sitzungsberichte der mathematisch-physikalischen Classe der königlichen bayerischen Akademie der Wissenschaften*, 1898, *pages* 3-18.

In the first place, the author completes and corrects the historical summary of earthquakes recorded in Bavaria which he published in 1889 in the Reports of the Proceedings of the Munich Academy.

He then summarizes the reports received as to the earthquake of January 5th, 1897, in the Bayerischer Wald. Shocks were perceived at different localities at 7·30, 7·45, 7·50, and 8 a.m., accompanied by a rolling noise as of thunder. The weather was perfectly calm and clear. No damage was done, except to a few rather shaky chimneys; and certain springs dried up for a time, and then ran muddy. The area covered by this earthquake was small; the direction of the shocks was from south-east to north-west, and this agrees with the strike of the gneisses of which that mountainous district is chiefly made up. The cause appears to be geotectonic—a release of strains among rocks at some depth below the surface.

On October 24th, 1897, began the long continued series of shocks which made themselves felt in the Erzgebirge, Vogtland and Fichtelgebirge. These districts

are frequently the *locus* of earthquakes, which appear to follow the lines of disturbance and fracture characteristic respectively of the Erzgebirge and Thuringerwald rock-systems.

Although at Carlsbad, in Bohemia, the vibrations were especially perceptible on November 7th, 1897, they do not appear to have influenced the flow of the mineral springs, either as regards quantity or temperature, and the same remark applies to the Frankensbad and Marienbad springs; evidently Carlsbad, at any-rate, lay at the extreme boundary of the earthquake-area. For many of the details regarding this particular earthquake, recorded from Graslitz across the Austrian frontier, the reader may also refer to Prof. Suess' paper, communicated to the Vienna Geologische Reichsantalt.* The last shock recorded was from Kulmbach on November 29th, 1897, at 3·30 a.m., during a thunderstorm accompanied by a heavy snowfall; thus the series of vibrations had continued more or less for a period of five weeks.

The author agrees with Mr. Credner, of Leipzig, that this earthquake belongs to the so-called tectonic group of phenomena, but he does not admit that it has anything to do with a loss of heat in the interior of the earth and a consequent wrinkling up or shrivelling together of the deep-lying rock-masses. He points out that in the area under discussion, through the great fractures which cross each other nearly at right angles, basalt-flows welled up at a late geological period, and in so doing shattered the rocks at no very great depth from the surface—in such wise that the slightest of causes, such as meteorological variations, would upset the condition of unstable equilibrium which resulted therefrom, and effect an alteration in the lie of the strata. This, he thinks, would sufficiently account for the shocks recorded in the late autumn of 1897.

The area affected covers about 1,000 square miles, but it is curious to note that it included belts of country in which no shocks were observed. Reliable data for the determination of the velocity of propagation were not obtained, one difficulty being the closeness with which the shocks followed upon each other.

L. L. B.

VELOCITY OF PROPAGATION OF THE PERGAMOS EARTHQUAKE, ASIA MINOR.

Velocità di Propagazione del Terremoto di Pergamo (Asia Minor) della Notte 13-14 Novembre, 1895. By G. Agamennone. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1898, *series* 5, *vol. vii., pages* 162-166.

This earthquake took place about 11·20 p.m. on November 13th, 1895, and the shocks were recorded by the Vincentini microseismograph at Padua, and the horizontal pendulum at Nicolaiev. From calculations made by the author, the mean velocity of propagation was 3,500 metres, or about 2·12 miles per second. The shocks appear to have travelled slightly faster than this to Nicolaiev, and somewhat slower to Padua. The author points out that this rate of travel agrees, on the whole, with the velocities of propagation of the Zante earthquake of 1893, and of the Paranythia earthquake of May, 1895; but it is much lower than the speed of travel of the Aidin shocks of August, 1895, and of the Ahmed earthquake of April, 1896. In the two last-mentioned cases, the Vincentini microseismograph at Padua registered 10 kilometres or 6·21 miles per second, and, moreover, the shocks were observed at Strasburg in Alsace. The violence of vibration appears to have been much less at the epicentrum of the Pergamos

* *Trans. Inst. M.E.*, vol. xiv., page 611.

earthquake, the epicentrum lay nearer the surface, the material damage wrought was far less considerable, and the shock does not appear to have travelled as far as Strasburg. Yet the Nicolaiev pendulum failed to record the far more violent Ahmed earthquake. The author, in conclusion, draws attention to a new factor which complicates the study of the propagation of seismic waves, namely, the dependence of the calculation of velocity on the actual intensity of the shock.

L. L. B.

THE RECENT EARTHQUAKE IN EMILIA, ITALY.

Il Terremoto nell'Emilia della Sera del 4 Marzo, 1898. *By* P. Tacchini. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1898, *series 5, vol. vii., page* 109.

This earthquake took place between 5 and 8 minutes past 10 p.m. on March 5th, 1898, and although it made itself felt over a very large area, no injury to life or limb or damage to property has been recorded. It is believed that the shock originated at a great depth below the surface, and that it came from the direction of the Apennines, being most violent between Piacenza and Modena, and fairly strong in the Garfagnana district, where it reached No. VI. of the De Rossi-Forel scale. At Siena, Rome and Ischia, the seismic waves, though not perceptible to the human organism, were duly recorded by the seismological instruments. Persons reported that they felt the tremors from Brescia and Salò in the north to Leghorn and Florence in the south, from Genoa and the Riviera di Levante in the west to Rovigo and Bassano in the east.

L. L. B.

INDIAN EARTHQUAKE OF JUNE, 1897.

Il Terremoto dell' India del 12 *Guigno*, 1897, *registrato in Europa. By* G. Agamennone. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1898, *vol. vii., pages* 265-271.

This earthquake took place in the afternoon of June 12th, 1897, and wrought great havoc in Central and Western Assam, and throughout Bengal, especially along the Assam boundary. The area over which damage was done was of enormous extent—reckoning from east to west (Jorhat to Patna) 560 miles, and from north to south (Darjeeling to Balasor) 370 miles. It is conjectured that the seismic focus lay at a considerable depth below the earth's surface, not less than 25 miles below, according to Prof. Omōri.

Opinions as to the cause of the earthquake vary. One authority thinks that it was due to movement along a line of fault which, passing through the southern slope of the Garo and Khasi mountains, runs on to Cachar and to beyond the Brahmaputra. Another traces a connexion between this earth-tremor and the continuous elevation of the Himalayas; while a third believes that it arose from a sudden break-down of the strata, caused by the injection of vapours or gases into the fissures existing in the earth's crust.

The maximum destructive force made itself felt at Cherra Punji, Teura, and Shillong, whence it it may be inferred that the epicentrum lay somewhere about 25 degrees north latitude and 91 degrees east longitude. The chief direction of propagation appears to have been towards the south-west. The duration of the shock, near the epicentrum, at Shillong was 2 minutes, and not less than 6 minutes at Calcutta—while the seismographic instruments at various European observatories registered perturbations for several hours in succession.

The author gives tables showing that the velocity of propagation to such far-off stations as Paris, Utrecht, Potsdam and Edinburgh, not to speak of various Italian localities, was very great indeed—something between 5 and 6 miles a second. The slowest undulations travelled at rather more than 1½ miles a second, and it is calculated that the soil rose and fell about 2 inches on their passage through it.

The author proposes to elaborate these conclusions in the Bulletin of the Italian Seismological Society. L. L. B.

UNDERGROUND ELECTRIC PUMPING-ENGINE.

Nouvelle Pompe électrique de la Fosse Lambrecht. By — Barry. *Bulletin de la Société de l'Industrie Minérale*, 1897, series 3, *vol. xi.*, *pages* 599-619, *and drawings.*

The Anzin Colliery Company required (1) to raise 5,500 gallons of water (25 cubic metres) to the surface from the depth of 1,186 feet (360 metres), and (2) to be able to raise the same quantity of water from the ultimate depths of 1,476 feet (450 metres) and 1,771 feet (540 metres). As all the space in the two shafts of the Lambrecht pit is otherwise occupied, it was not possible to employ an engine on the surface, so that it became necessary to resort to an underground pumping-engine, while for driving it electricity was preferred to steam for the following reasons:—The 300 feet (90 metres) heights of workings are of short life (6 to 7 years) and the underground pump would have to be shifted at the end of each of these periods, while with electricity all that would require shifting would be the pump and its electromotor, occupying but slight space and costing comparatively little for the engine-room.

Comparison between a steam and an electric-driven pumping-engine shows that (1) the mechanical efficiency of the latter, 50 per cent., is lower than that of the former, which is generally 70 per cent.; (2) loss by condensation in the steam-pipes greatly reduces the efficiency of the steam-driven pump, while the steam must be kept in the pipe even during stoppages, thus leading to further loss; (3) there is great difficulty in maintaining the lagging of the steam-pipes, whereas no such difficulty occurs with electric cables; (4) the steam pump is only convenient when it can work with condensation, which is not possible at great depths, so that space must be provided in the old workings for receiving the exhaust steam, while the electric pump may be employed at any depth; and (5) the steam pump greatly heats the air of the underground engine-room, necessitating a special air-current unless the heated air be sent into the workings, while this difficulty does not exist with the electric pumping-engine.

The installation consists of (1) on the surface, a steam-engine driving by belt the generating dynamo; (2) in the shaft, two cables for leading the current and a rising water-main; and (3) underground, an electromotor with force pumps. The characteristic features of the power transmission are continuous current of 500 volts tension, and electromotors of reduced speed. This voltage was chosen because, with a force of 80 horsepower to be transmitted to about 1,310 feet (400 metres), it was desired to reduce as far as possible the loss of energy in the line, and this might be effected by either a high voltage or a cable of large diameter. A potential of more than 500 volts would have been difficult to maintain, as regards the insulation; and a cable of large diameter would have been costly, so that dynamos at moderate speed were selected.

The author describes the plant, including a Raffard coupling, which gives a

certain amount of elasticity between the electromotor and the pump, while at the same time preventing accidents to the dynamo in the event of unusual resistance in the pumps.

The following precautionary measures were taken for preventing mistakes in working:—(1) In case the water-level should fall sufficiently to expose the wind-bore of the suction-pipe, a float in the sump will lift a hook that keeps the lever of the rheostat in the position of working, so as to introduce resistances into the circuit and ultimately to stop the pump. (2) For making sure that the magnets are energized before current is sent into the armature of the electro-motor, there is on the underground switch-board a coil of fine wire traversed by the current for exciting the dynamo. If there be any magnetic field this coil will attract its armature, and the latter will permit of placing the bi-polar interrupter in the position for working; but, in the contrary case, the armature will engage with the interrupter so that it cannot be moved. (3) On the same switch-board, is a second fine-wire coil traversed by the exciting current of the dynamo, and when this coil is magnetized it keeps the handle of the rheostat in the position for working. If, however, the magnetic field should disappear from any cause, a counterweight would bring the handle of the rheostat from right to left, thus releasing the interrupter. It is important that, in the event of stoppage on the surface without notice to the underground engineman, the electro-motor be automatically switched out of circuit so that, on its being again started, the generating dynamo may not be in electric connexion with the electro-motor without the latter having been previously excited. (4) For preventing the possibility of the underground pump being stopped without notice to the surface engineman, an electric bell in the surface engine-room will be made to ring on there being a deficiency of water in the condenser cistern.

The total cost of the plant is £2,916 12s. 10d. (72,916 francs). Two experimental trials lasting 1 hour each showed that, with condensation, the efficiency of the plant averaged a little over 50 per cent., and that the mean ratio between the work in water raised and the effective horsepower furnished to the generating dynamo was 71·5 per cent. J. W. P.

USE OF ELECTRICITY IN THE FIERY MINES OF BELGIUM AND WESTPHALIA.

Note sur la Réglementation des Emplois de l'Electricité dans les Mines à Grisou en Belgique et en Westphalie. *By* A. Leproux. *Annales des Mines*, 1898, series 9, vol. xiii., pages 45-149.

During the last few years the applications of electricity have become numerous in mines, both for lighting and for the transmission of energy in various forms, while the number of applications appears to increase daily. From a purely economical standpoint, the question of power transmission by electricity presents various advantages and disadvantages just as much in mines as in any other branch of industry; but as regards safety one of the disadvantages acquires great importance, viz., the danger arising from the easy transformation of electric energy into heat.

In Belgium, the existing installations are confined to down-cast shafts and intake air-ways, where the presence of fire-damp, even in infinitesimal quantities, is very problematic, so that there only remains the danger of fire, which is combatted by means which are neither new nor special to mines, although they may perhaps be applied more systematically. Special measures, such as the casing of

dynamos, the use of safety cables, and the enclosing of switches have hitherto conformed to the letter only of administrative prescriptions.

If the applications of electric energy in fiery mines are not very extensive in Belgium, they are relatively far more numerous in Westphalia; but in neither country do there exist power transmission plants, any portion of which is exposed to a decidedly fiery air-current. In fact, the only dangers that have had to be met are those of fire and of shock on contact, and the administrative measures bearing upon them do not differ from those found necessary in surface installations.

As to the danger of igniting gaseous or dusty mixtures, the author's opinion is that it has hitherto been dealt with only as a matter of form; and the measures taken are, in Belgium, a thorough enclosing of parts capable of giving out sparks, together with the use of special cables; and, in Westphalia, the use of polyphase currents and of motors without brushes, together with strongly armoured cables. In both countries, the government requires that previous authorization be obtained, and the installations are subjected, at any rate ostensibly, to regulations that are far stricter in Belgium than in Germany. J. W. P.

FURTHER EXPERIMENTS ON THE EXPLOSION OF FIRE-DAMP MIXTURES BY THE ELECTRIC SPARK.

Sur l'Explosion des Mélanges grisouteux par l'Étincelle électrique: Principe de la Dérivation du Courant. *By* H. Couriot *and* J. Meunier. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences, Paris,* 1898, *vol. cxxvi., pages* 901-904.

In a previous paper,* the authors had shown that fire-damp mixtures are exploded by the current-breaking spark, and here they show that under given conditions, even this spark may be produced without exploding the gaseous mixture. This curious result is obtained by joining up, by means of a secondary conductor, two of the points of the conductors between which the spark arises. When, however, the ratio of the resistances is expressed by a high value, or, in other words, when the resistance is very considerable in the parallel branch, the current-breaking spark invariably brings about an explosion. The corollary to this is that, when the spark takes place in a single circuit, the breaking of which determines the complete extinction of the current, explosion is the inevitable result. With the finest silver wire obtainable in commerce (0·002 inch or 0·05 millimetre thick) and very feeble currents, the spark was produced and was followed by explosion of the gaseous mixture. On the other hand, explosion is the more easily avoided, the nearer the ratio of the resistances approaches unity: both above and below this value there is, as it were, a boundary-line within which explosion is avoidable. L. L. B.

EXPLOSIVES FOR FIERY MINES.

Sprengmittel mit Rücksicht auf ihre Verwendung in Schlagwetterführenden Gruben. *By* J. Von Lauer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 689-697, *and* 703-715.

High explosives are alone suitable for use in fiery mines, and the charge must in each case be accurately adjusted so as to develop the exact disruptive power required to rend the rock, coal, etc., without there being any excess of force to cause a blown-out shot and produce ignition of fire-damp. The proportioning of the

* *Trans. Inst. M.E.*, vol. xiv., page 635.

charge to the work is effected by measuring the distance in metres from the bottom of the bore-hole to the face, along a line at right angles to the latter, and multiplying the cube root of this length by a factor (variable for each class of rock), the result giving the weight of the charge in kilogrammes. A table of charges for rock coefficients from 0·05 to 0·50, and for radial lengths from 0·25 to 1 metre (10 to 40 inches) is given in the paper.

The author considers that, so far as stemming is concerned, sufficient safety can be ensured by the careful application of clay or sand, water-cartridges reducing the power of the explosive, and all substances that require special preparation before use being inconvenient.

The explosion temperature of fire-damp being 3,992° Fahr. (2,200° Cent.), those explosives developing a higher temperature must be excluded, in order that perfect safety may be ensured, a condition that consequently precludes the use of nitro-glycerine, kieselguhr dynamite, new dynamite, and favierite No. 1. The greatest degree of safety attaches to nitrate-of-ammonia explosives, their explosion temperature being low, whilst they do not deflagrate if the fuze be too weak to produce an explosion. On the other hand, their low specific gravity and their hygroscopic tendencies are disadvantages, to which must be added their low disruptive force, which necessitates the use of charges three times as large as when dynamite is employed. The author, therefore, expresses the opinion that, provided the holes be sufficiently well stemmed, and the amount of the charge carefully adjusted to the work it has to do, any explosive that is free from incombustible and non-volatile matter can be used with safety. Other necessary conditions are: The employment of central detonators containing a due proportion of fulminate of mercury, and a proper depth of stemming in the bore-hole, the minimum being 1 or 1½ times the longitudinal space occupied by the blasting cartridge.

C. S.

SAFETY-IGNITERS FOR FIERY MINES.

Gefahrlose Zündung von Sprengstoffen auf Schlagwettergruben. By Bergassessor Gerlach. *Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande, Westfalens, und Osnabrück*, 1897. *vol liv.*, *pages* 24-34.

Premising that the explosives nowadays most used in Germany are westfalit, dahmenit, roburit, safety blasting-powder and carbonit, with dynamite water-cartridges, the author proceeds to review the history of the introduction of safety-igniters. He points out the defects which practical use brought to light in the Lauer and Firrmann igniters, and then describes the Roth, Norres, Hohendahl, and Kost systems.

The Roth and the older Norres igniters consist essentially of a metallic cylinder, closed at one end, and containing in the case of the latter a wire spirally twisted at one end, in contact with a percussion-cap. The friction set up when the wire is pulled starts the ignition, while it is intended that the touch-flame should not travel outside the cylinder—a desideratum not always attained in practice. In the Roth igniter, the cylinder contains a bulb filled with sulphuric acid, between which and the fuze-end is inserted a mixture of potassium chlorate and sugar: on contact with the sulphuric acid escaping from the broken bulb, a sufficiently high temperature is evolved to ignite the fuze. In this case, the initial flame is confined to the cylinder. Neither of these igniters, however, have been found in practice to do away with the risk of setting fire to pit gases.

The Hohendahl igniter is essentially a clip or pair of pincers or tongs, scooped out so as to receive the fuze-end and the percussion-cap thrust upon it. The

closing of the tongs releases a spiral spring, which brings down a small bolt on the cap, thus igniting the fuze. The workman must hold the tongs down on the fuze till the latter has ceased sparking. The touch-flame is received in the scooped-out portion of the clip, and small channels bored in the same allow the gases evolved from the powder to escape.

The Kost safety-igniter consists in the first place of a large metallic cylinder closed in front by a lid, perforated to admit the fuze ; the other end is closed by the striking apparatus. Like the Hohendahl clip, this igniter also must be kept down on the fuze till the latter has ceased sparking. Both igniters, therefore, can be entrusted only to very steady, intelligent men, and they need careful cleaning after each ignition. These and other requirements, not always easy of fulfilment in practice, have proved insurmountable obstacles to the general use of such apparatus.

In Westphalia, they have returned to the system of ignition by electricity. Unfortunately, the experiments made at Gelsenkirchen and Neunkirchen have proved that if the wires be suddenly sundered, as may well happen in the case of falls of rock, the resulting spark is sufficient to explode fire-damp mixtures.

On the other hand, extremely satisfactory results are recorded from the experiments made at Wittenberg by the Westphalian-Anhaltian Explosives Company, primarily on the initiative of Bergrath Lohmann. The fuze employed there is made of nitrocellulose, with a covering web of jute, and the outermost band is soaked with paraffin as a protective against damp. The fuze is impregnated with a drying oil, and with salts which give off much oxygen (chromates, manganates, etc.) and such as contain much combined water in the form of crystals, with the view of reducing if not altogether stopping any outburst of flame. The fuze burns at the rate of 39 inches in 35 to 40 seconds, if compressed or nipped it goes out immediately, and it can be kept for a fortnight in the pit without apparently suffering from damp. The shot-firers in the König pit used it with clay stemming on a large scale for three weeks, and they reported that they had not had a single miss-fire. The author thinks that here at last we have the ideal safety-fuze for fiery mines, superior to all others for its simplicity and for the ease with which it can be handled. L. L. B.

LESSONS TAUGHT BY TESTS ON SAFETY EXPLOSIVES.

Les dernières Expériences Allemandes sur les Explosifs de Sureté. By VICTOR WATTEYNE. *Annales des Mines de Belgique*, 1897, *vol. ii., pages* 888-898.

After recounting the results of Bergassessor Heise's experiments * with various safety explosives, including one in which three of them caused the ignition of coal-dust alone, just as readily as that of the most dangerous mixtures of air and fire-damp, the author remarks that this fact only constitutes another proof of how readily inflammable is very fine coal-dust rich in bituminous matters, and how real is this special danger, while he draws the following conclusions from the collective experiments :—

The testing of explosives is a very delicate matter, into which too great care cannot be introduced for avoiding error ; and in erecting a testing-station nothing should be neglected for ensuring that the tests made therein should be conducted under the best possible conditions. In this connexion it may be asserted that a testing-station has greater disadvantages than advantages unless it is more complete and perfect than previous stations.

* "Further Experiments with Explosives at Gelsenkirchen. *Trans. Inst. M.E.*, vol. xiv., page 644.

What are called safety explosives have not yet attained, and probably never will attain, any more than a relative degree of security. It is evident that there should be no hesitation in preferring safety explosives to blasting-powder and ordinary high explosives, when the use of explosives cannot be entirely avoided; but the fact should not be lost sight of that the danger of explosion, if diminished, still exists. Accordingly, far more will be done for ensuring the safety of a mine by suppressing the use of explosives for dangerous works, such as bringing down coal and ripping the roofs and floors of roads, than by employing for these operations the most perfect safety explosives hitherto invented. J. W. P.

MECHANICAL WEDGES FOR MINING MINERAL.

(1) *Notice sur l'Emploi de l'Air comprimé pour le Creusement des Roches.* By Joseph François. *Revue Universelle des Mines, etc.*, 1897, *series* 3, *vol. xxxix.*, *pages* 97-144.

In the hope that, at no very distant date, the great question of the suppression, if not absolute at any rate to a very considerable extent, of explosives in the working of collieries may be finally settled, the author has written this notice in connexion with the appliances shown by him at the Brussels Exhibition of 1897. After describing the air-compressor and rock-drill, with the successive improvements introduced into them, he observes that the results obtained with mechanical rock-drilling differ greatly according to tho conditions under which the work is carried on. In mines, as a rule, what he calls "normal" working is adopted with a view to keeping down the cost, while in other cases, as in driving tunnels, when rapidity is the great point, "forced" working must be employed. He gives a comparative table showing the results accomplished when driving in shale, ordinary sandstone and limestone, granite and hard sandstone, and also in quartz and porphyry by (1) ordinary methods, (2) rock-drills with "normal" working, and (3) rock-drills with "forced" working, observing that, for obtaining rapid advance, it is not sufficient to merely take into account the effect of the rock-drills, but all the operations must be executed promptly without interruption and by a sufficient number of hands.

After dealing in detail with the operations in "normal" and "forced" working, the author describes the driving of cross-measure drifts, and also the ripping of roof and floor in coal-headings without the use of explosives, giving tables of works actually carried out, with the expenditure of labour and of compressed air, by the aid of the bosseyeuse, or mechanical rock-drill which (1) makes a hole in the working-face, and (2) drives in a multiple wedge for bringing down the rock. He also describes some comparative trials, with their results, in driving a road and airway in the same seam, one by the bosseyeuse and the other by hand and with the use of blasting-powder.

In another and similar comparative trial, the advance per shift was 6·4 feet (1·93 metres) with powder and 7·3 feet (2·25 metres) with the bosseyeuse, the daily advance being over 1 foot (32 centimetres) more with the latter; and, if the cost was a little higher, that is explained by the machine-men having received higher wages. The rapidity of the advance by mechanical means is due to the short time required to drill the hole; and it is pointed out that (*a*) the harder the rock the more marked is this advantage and (*b*) the larger the quantity of rock to be removed in proportion to the thickness of the seam the greater also is this advantage.

From the detailed trials recorded in the paper and others described by Mr. Dubois, general manager of the Marihaye colliery, the latter deduces the three following conclusions :—(1) The introduction of compressed air and mechanical appliances into fiery mines affords extraordinary assistanee, as regards safety and in preparatory workings, because of the supplementary ventilation thus introduced. (2) The ripping of roof and floor by the bosseyeuse is more rapid than with the ordinary methods by hand and with blasting-powder, without being more costly, and it permits of such advances in thin seams as to render their working remunerative. (3) The driving of cross-cuts by the bosseyeuse is always sufficiently rapid, since the advance is equal to that by blasting, and the speed can always be increased by putting on two machines instead of one.

(2) *Keilvorrichtung zur Hereingewinnung von Kohle oder Gestein.* *By* Bergassessor F. Heise. *German Patent*, *No.* 95366, 1897.

In the form of wedging arrangement in which two wedges are drawn towards one another between a pair of plugs by a screwed spindle, the wedges often become jammed owing to the unequal resistance, so that the plugs are not forced apart regularly over their whole length ; and it often happens that, on the screw being drawn back, the more tightly-jammed wedge remains in the hole while the other only is brought back.

The Heise arrangement assumes two forms, in one of which the spindle has a right-handed and left-handed thread, while the female screws are not cut in the wedges themselves, but in nuts inserted in them with a little play. The screw-spindle has a collar in the centre for preventing longitudinal slip between the spindle and the plugs, which are made with corresponding recesses, and also with projections for preventing the plugs from sliding over the collar when in their extreme position.

In the other form, the two wedges overlap one another, head to point, and the plugs are parallel, one wedge and one plug forming a complete whole. A drawing together of the two wedges by the right and left threaded spindle forces the two plugs apart regularly and in a parallel direction. In this case, however, the spindle need only be threaded at one end for drawing forward one wedge, the other being held in place by a recess receiving a corresponding collar on the spindle.

In both forms, when the desired effect is not produced by a single drawing together of the wedges, they may be returned to their original position without difficulty or loss of time ; and, if the rock substance should be compressed, so as to enlarge the hole, the operation may be repeated after the insertion of a supplementary plug. J. W. P.

EXPLOSIVE MAGAZINES SUNK TO SLIGHT DEPTHS.*

Commission des Substances explosives : Rapport sur les Expériences de Blanzy du 7 Août, 1897; *Etude des Conditions d'Etablissement des Dynamitières souterraines.* *By* J. Biju-Duval. *Annales des Mines*, 1898, *series* 9, *vol. xiii.*, *pages* 644-663, *and* 1 *plate.*

The previous experiments of the Commission, although necessarily carried out on a small scale, gave results so uniform and regular as to permit of its formulating the following laws :—(1) The external effects caused by the explosion of a given charge are independent of the density of its distribution, provided that the thickness of earth covering the magazine be the same. (2) For variable charges,

* *Trans. Inst. M.E.*, vol. xiv., page 641.

the distances to which matters are thrown forward on the surface remain practically of the same order when the thicknesses of earth covering these charges is proportional to their square root. (3) If the explosion of a closely-packed charge, placed at a certain depth, forms the ordinary funnel-shaped excavation, the same charge, at the same depth but spread over a length equal to about five times the line of least resistance, will only cause external effects of far slighter intensity. (4) In the case of an elongated charge, in which the same weight per unit of length is preserved, and with the same earth-cover, the external effects will increase with the total charge up to a certain limit, which would appear to be attained by spreading out the charge to a length of three or four times that of the line of least resistance.

Inasmuch, however, as the experiments of the Commission were limited to charges of 70 pounds (32 kilogrammes), that body considered that a few experiments on a large scale were required to verify the attenuation observed in the external effects of explosions owing to an increase in the thickness of the earth-cover or to an elongation of the charges; and such experiments were carried out, with the co-operation of the Blanzy Mining Company, on August 7th, 1897. Inasmuch as it was desired to see the effect caused by exploding quantities of dynamite such as might be actually stored in magazines, charges of 10 cwts. (500 kilogrammes) of No. 1 dynamite, containing 75 per cent. of nitro-glycerine, were adopted in all of the four cases. In two of the experiments, the charge was packed closely in a magazine of as small dimensions as possible, being placed in one case 29½ feet (9 metres), and in the other case half that depth below the surface, while in the two other experiments the charge was spread out to a length of 82 feet (25 metres), under 15 feet (4·5 metres) of earth in one case, and 10 feet (3 metres) in the other. The object of the first two experiments was to set at rest the influence exerted by the earth-cover above the magazines; and that of the two others, the influence of spreading out the charges in length, while the lengths of the galleries were so calculated as to be well outside the limit beyond which the external effects appear to remain constant when the length of the charge increases, such charge remaining constant for the length unit.

This second series of experiments at Blanzy confirmed, and in a sense rather favourable than otherwise, those previously carried out; and the Commission is of opinion that the rules to be followed in establishing magazines at a slight depth below the surface, and not communicating with the workings of a mine, may be formulated from the whole facts acquired, so as to obtain the best conditions. The dangers to be guarded against from the accidental explosion of such a magazine are of three different orders as follows:—(1) All the experiments show that the action transmitted through the earth is neutralized at a very slight distance. (2) The vibration communicated to the surface is insignificant; and the effects may be localized and deprived of danger for the immediate neighbourhood by making the approach drift debouch into a trench before a merlon (or shield), containing a chamber for receiving and retaining the matters thrown forward. (3) Two principal cases have to be considered, either the land at disposal is of such nature and configuration that the magazine may be placed at such a depth that, on an accidental explosion taking place, no funnel-shaped excavation will be formed or matters thrown up on the surface; or, on the other hand, the magazine can only be placed at a relatively slight depth, when the matters thrown up must be guarded against. In the former case, experiments show that, if a powder charge at a certain depth acts like an ordinary mine, an equal charge of dynamite at double that depth in the same soil will produce no effect

and from these data it is possible to calculate the thicknesses of earth to be kept above the magazine so as to prevent any matters from being thrown forward.

Tables are given (in the original communication) showing the thickness of earth that should be left in various soils and for various charges, both when packed closely and when distributed over a certain length. As to the second case, a further table is given of thicknesses to be preserved when there is reason to fear the throwing up of matters; and it is remarked that even a slight thickness of earth lessens the report of an explosion, and prevents damage through vibration of the air, even at very slight distances.

The matters thrown forward in the Blanzy experiments may be divided into two distinct classes:—(1) Those that may be called dense which, even in the most unfavourable cases, covered only a slight area; and (2) those called isolated, some of which fell at an appreciably greater distance. The heavy and dangerous substances, such as bricks from the lining of magazines, generally fell within the funnel-shaped excavation itself; and it was only small clods of earth of slight weight that were projected to greater distances, so that the Commission is of opinion that they may be disregarded.

If there be not at disposal land with uniform and friable soil without large stones, the portion above the magazine must be replaced by suitable filling, consisting solely of sand, gravel, or very sandy soil, for a thickness of 10 feet (3 metres) below the surface; and rules are given for determining the width of this filling in various cases.

The Commission concludes that the considerations in its report, with the data given in the tables, will permit, in various cases that may present themselves in practice, of determining the best conditions for establishing magazines below the surface; and it calls special attention to the great progress made by sinking magazines below the surface, the Blanzy experiments having shown unmistakably the great advantages, as regards safety to the neighbourhood, possessed by such magazines over those now erected on the surface, notwithstanding all the precautions and regulations imposed. J. W. P.

PRECAUTIONS AND RULES TO BE OBSERVED IN CASES OF EXPLOSIONS IN THE COAL-MINES OF OSTRAU, MORAVIA.

Vorkehrungen und Massnahmen für den Fall eines Eintritts von Schlagwetter-Explosionen auf den Steinkohlengruben im Bezirke des K. K. Revier-Bergamts Mährisch-Ostrau. EDITORIAL. *Glückauf*, 1898, *vol. xxxiv.*, *pages* 296-299.

The Imperial department of mines of Vienna has issued a regulation dated April 6th, 1897, concerning the precautions to be observed in dealing with an explosion of fire-damp or a pit fire. In the first place, there must be a station as near as possible to the travelling-shaft, at which are to be kept suitable appliances for respiration in noxious gases, together with electric lamps, spectacles for protecting the eyes, and brattice-cloth or other means for rapidly restoring the ventilating current. A responsible official is to be in charge of this station, and the number of respirators shall be 5 per cent. of the maximum number of men employed per shift, but never less than 10. Twice this number of men must be trained in the use of the above appliances, and they must be equally distributed in the various shifts.

The manager has to see that certain officials are told off to definite duties at the surface in case of an explosion; one of these has to see that the rate of the fan is not altered, as an increased speed may be injurious; medical assistance is to be

at once sent for, relief gangs are to be organized, the men coming out of the pit are to be carefully registered, the inspectors are to be notified, assistance requested from neighbouring pits, and admission to the colliery refused to casual visitors.

The action to be taken underground depends on whether the pit has or not been set on fire by the explosion; in the former case, if it be considered probable that men remain alive in the pit, volunteers should be called for to attempt to save them. If it be unlikely that any men in the pit have survived the force of the explosion, attempts should be at once made to quench the fire. If there be no fire, each relief gang should be divided into two sections, one to advance as quickly as possible, and the other to follow and restore the course of ventilating currents.

The manager must see that sufficient supplies of brattice-cloth and other material is sent down; he must organize relay gangs to take the place of or to supplement the first relief gang; he must receive the reports of the overmen who come out with their men from the unaffected portions of the pit; he must see that men acquainted with the pit are sent to the various crossing points to indicate the right road to men making their way back, and that a sufficient number of electrical or safety-lamps is sent in to illuminate the line of retreat and the pit-bottom. After this, he may go down to take charge of the relief operations, but he must first appoint a representative at bank. H. L.

REASONS WHY THE OBJECTS OF FIRE-DAMP COMMISSIONS HAVE NOT BEEN WHOLLY ATTAINED.

Le Grisou étudié dans ses Rapports avec les Phénomènes de la Météorologie endogène et au Point de vue de sa Prévision par l'Observation des Microsismes: Exposé des Motifs. By Ernest Van den Broeck. *Société Belge de Géologie, de Paléontologie et d'Hydrologie, June 14th,* 1898, 14 *pages.*

The causes which have rendered partially unproductive the efforts of official and other fire-damp commissions in various countries are of two kinds. In nearly every case official commissions have had placed before them restricted programmes, drawn up under the influence of predetermined conditions, or requiring for their execution considerable pecuniary resources. The second cause of non-success is complex. In the first place, the investigations, the scope of which has been too much restricted beforehand, have often been confined to the investigation of subsidiary matters; but, above all, sufficient account has not been taken of the aid which a new science has, during the last few years, placed at the disposal of investigators.

To the officials and engineers forming part of future commissions should be added specialists in geology, endogenous meteorology, and seismology, as well as physicists and any individuals who could lead the investigations into new and unexplored channels. At the same time, the resources should not be doled out with too sparing a hand, while all the means necessary and all new methods of investigation should be officially permitted, with a view to secure attainment of the object.

Now that this double stumbling-block is clearly pointed out, it may be hoped that in future beaten tracks will be abandoned, both in the drawing up of programmes for the study of fire-damp and in the composition of the commissions, as also in their attributes and in the scientific and other resources placed at their disposal. J. W. P.

FIRE-DAMP AND METEOROLOGY.

Du Grisou dans ses Rapports avec la Météorologie endogène. By EMILE HARZÉ. *Pamphlet*, 17 *pages*, *Brussels*, 1898.

An exposition by Mr. Ernest Van den Broeck* as to fire-damp in its relations to the phenomena of endogenous meteorology and as regards its forecast by the observation of minute movements of the earth, made to the Belgian Society of Geology, Palæontology and Hydrology, having appeared to the author to contain rash if not erroneous statements, and also of a nature to cause misconception as to the efficacy of efforts made by coal-masters and mine inspectors in combating fire-damp, he thought it necessary to intervene in the debate.

He considers that the quantity of fire-damp with which a seam is, or can be, impregnated varies from one point to another, being in direct ratio to the degree of porosity of the coal and its schistose intercalations. Owing to the thrust which folded the Coal-measures, the plasticity of the clay-beds and a kind of swelling in the vegetable substances in course of being mineralized have filled up the spaces which had a tendency to form at the various folds and counterfolds; and thus is explained the existence of portions of a seam less compact than others, and consequently more impregnated with fire-damp. These veritable nests of gas would burst like *lacrimæ batavicæ* (Prince Rupert's drops), while throwing forward pulverulent daloid coal and giving out a large quantity of gas, on the natural equilibrium being upset by the advance of mine-working. These fire-damp nests, very numerous in some deposits, form a source of great danger; but they are generally emptied with greater or less facility under the influence of the draining which is effected by a rational mine-working, and also by advance holes for bleeding the seam. The natural fractures, the texture of the coal, and the cleavage joints also play an important part in taking off the gas.

Although the author admits that the fire-damp question is by no means set at rest, he cannot allow that the law regulating sudden outbursts is entirely unsolved; nor can he believe that the labours of fire-damp commissions, as regards Belgium at any rate, have been without result owing to a too restricted programme, although the realization of a whole programme by an official commission or by individual effort is quite another matter. Nor can he conceive that so many observations, researches, and experiments have been entirely without effect as regards protection of the workman against sudden outbursts; on the contrary it has been possible to indicate methods of laying-out workings and measures to be adopted which diminish the frequence and violence of the manifestations in question, and also to make such arrangements that, on the manifestations occurring, the men exposed to them more frequently than not escape disastrous consequences.

In Belgium, statistics bearing upon all the fatal accidents due to fire-damp, viz., ignitions (explosions), the violent throwing forward of coal, and asphyxiation without ignition of the gas, can only be compared for two 10-yearly periods, viz., 1881-1890 and 1888-1897, which have three years in common, viz., 1888 to 1890. In the former there were 5·79 deaths per annum per 10,000 underground workpeople, which, during the second, fell to 4·11, showing a diminution of 29 per cent., notwithstanding the fact that two serious accidents occurred during the second period. It may be added that the last 5-yearly period, from 1893 to 1897 (which is characterized by increased efforts on the part of coal-masters to suppress the use of explosives, or at anyrate to restrict it to those of slow action, and also,

Trans. Inst. M.E., vol. xv., page 531.

for the last 2 years by the application of new regulations as to explosives) has been particularly favourable, since the proportion of deaths owing to fire-damp has only been 1·37 per 10,000 underground workmen, and 1·01 per 10,000 surface and underground workmen together per annum; and these proportions would be reduced to 0·61 and 0·41 respectively if only those accidents were taken into account in which ignition of fire-damp occurred.

The author does not consider that sudden outbursts of fire-damp can be connected with an internal cause acting with a certain degree of intensity over a large area; and he finds no proof of the connexion. supposed in the exposition, between the sudden outburst at Ciply, in Belgium, with that at Micklefield, in England, or with the storm on the following day.

Rather than adopt Mr. Forel's recommendation to redouble precautions against fire-damp, on days following an earthquake, in a mine to which the seismic area extends, the author considers the following as far more essential:—Redouble precautions when a cross-cut strikes a coal-seam that has the reputation of sudden outbursts; if the portion of seam in which the face is advancing has not been bled by previous workings; when the normal disengagement of fire-damp ceases, and also if the seam is free from continuous schistose intercalations forming a drain; while always arranging the working-places so that the daily advance may be only moderate, and so as to afford a large passage for an abundant fire-damp disengagement if it should occur.

Never, in Belgium, do sudden outbursts occur during stoppage of working, on Sundays for instance; and, although on Mondays the effects of internal action may be noticed, they are not the mechanical effects which characterize sudden outbursts, so that, if the phenomenon be due even partly to terrestrial vibration, its field of appreciable influence must be very limited. The internal auscultation proposed appears, however, to the author so valuable that he hopes methodical investigations into minute movements of the earth will throw fresh light on what is already known as to fire-damp; and, if extended to the phenomena of terrestrial magnetism, they will aid in perfecting underground geodesy. Subject to the above reserves, therefore, he will be happy to take part in the proposed work, with the hope of lessening the number of mining fatalities. J. W. P.

EARLY MENTION OF FIRE-DAMP.

Geschichtliches über die Entwicklung des 800jährigen Steinkohlenbergbaues an der Worm. *By* Franz Büttgenbach. *Published by Ignaz Schweitzer, Aachen,* 1898, *pamphlet,* 29 *pages and map.*

Canon Ernst, who was choir-master at the Klosterrath abbey, when it was suppressed in 1795, and who wrote a history of Limburg between 1800 and 1810, forming a continuation of the abbey annals compiled by the 35th abbot, Nicolaus Heyendahl, between 1712 and 1733, remarks as to fire-damp that its true nature was not thoroughly understood, calling it in the French of the period *vapeurs enflammentes et quelquefois fulminantes.* This observation warrants the belief that, even at that early time, a distinction was drawn between two kinds of damp *(wetter);* and *enflammentes* (remarks the author) well describes the atmosphere impregnated with coal-dust *(staubkohlen-atmosphäre),* and *fulminantes* that of the inflammable explosive gases, because otherwise why this distinction? It is wellknown, he continues, that the explosive nature of coal-dust was not known until the second half of the present century; and therefore the distinction drawn

by Canon Ernst is very interesting for that early period. The occurrence of inflammable gas was at that time regarded as due to meteorological phenomena; and the designation of *météors inflammables*, even if not quite understood, may have originated in correct observations, as it is even now proved that barometric variations, which are certainly due to meteoric action, may cause fire-damp outbursts, J. W. P.

SUDDEN OUTBURST OF FIRE-DAMP PREVENTED BY ADVANCE BORING.

Charbonnages Réunis de l'Agrappe, Puits No. 2: Dégagement de Grisou dans un Touret montant. By J. DE JAER. *Annales des Mines de Belgique*, 1897, *vol. ii., page* 902.

When the rising of the small shaft put up from the south cross-cut, 2,300 feet (700 metres) deep, for letting down the coal got from the Epuisoire seam between the horizontal fault and the level of 2,100 feet (640 metres) had attained the height of 82 feet (25 metres), a third fall occurred with disengagement of fire-damp; and Mr. Stassart (assistant inspector of mines) reported the circumstances in detail as follows, because the precautions taken probably prevented a sudden outburst:—

On June 30th, 1897, a bore-hole, after having passed through 5 feet 10 inches (1·8 metres) of hard rock, encountered a mixture of coal and very carbonaceous shale. Four fresh holes were then bored upwards, passing through 2 feet (60 centimetres) of the above-named mixture. Work was suspended for three days, and then blasting was resorted to for reducing the thickness of the shale between the top of the staple pit and the seam to 3 feet (1 metre). On July 8th, five more holes were bored upwards, which passed through the carbonaceous shale; and, after waiting two days, the men began to take out the shale with the pick on the southern side, or towards the lower part of the slightly inclined seam. On July 14th the very carbonaceous shale was reached, in which nine holes were bored, diverging upwards, after which work was interrupted for another three days. The bed of shale was then reduced by the pick on the northern side, or towards the rise of the seam; and on July 21st eight more holes, diverging upwards, were bored in the carbonaceous shale, a work which was continued on the following day. On the 23rd, however, as four men and an overman were engaged in timbering and were about to place a rail for supporting the ladders, a creep occurred without any unusual noise, and a large quantity of small pieces of rock fell from various parts of the roof. The overman immediately made the men descend, and as they reached the bottom of the staple they heard the fall of rock, and became aware of the presence of a certain quantity, though not very large, of fire-damp. The lamps were not extinguished, and the men were able to make their way towards the winding-shaft. The overman, who had gone by the ladder shaft to the level of 2,000 feet (610 metres), returned therefrom with another man; but, on his reaching the level of 2,300 feet (700 metres), the quantity of fire-damp had increased, although ½ hour after the accident they were able to gain the foot of the staple without their lamps being extinguished. Fifty tubs of spoil, chiefly consisting of stone, were removed; and a cavity was perceived, 13 feet (4 metres) long, beyond the point where working had been stopped. J. W. P.

ABSORPTION OF GASES BY ELECTROLYTICALLY-DEPOSITED METALS.

Einiges über Metall-Niederschläge. *By* F. Winteler. *Zeitschrift für Elektrochemie*, 1898, *vol. iv.*, *pages* 338-341.

Many metals (*e.g.*, nickel) form a scaly deposit when a certain thickness of film is attained, a mass of spongy or pulverulent consistency being formed by others when certain limits of current density are exceeded, copper affording an example of this latter category. In the case of nickel, the difficulty can be surmounted by the employment of bath temperatures ranging from 50° to 90° Cent.

Iron deposited by electrolysis contains a large proportion of gas (as much as 164 times its own volume), chiefly hydrogen, associated with nitrogen, carbon monoxide and carbon dioxide. This gas renders the plates extremely brittle, but when ignited this peculiarity disappears and they become pliable. The relative amount of gas absorbed appears to vary inversely with the thickness of the metallic film.

Copper, on the other hand, absorbs, under similar circumstances, only 4·4 times its volume of gas, three-fourths of which consists of hydrogen. However, when the electrolyte is kept hot during the operation, the deposited metals are free from gas.

Nickel has a high absorptive capacity, taking up 165 volumes of hydrogen when employed, in the cube form, as a cathode for the electrolysis of dilute sulphuric acid. C. S.

CHARACTERISTICS OF A GAS-COAL FROM THE NORTHERN COAL-FIELD OF NEW SOUTH WALES.

Characteristiques d'un Charbon à gaz trouvé dans le Northern Coal-field de la Nouvelle Galles du Sud. *By* C. E. Bertrand. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1897, *vol. cxxv.*, *page* 984.

This coal differs greatly from the kerosene shale found in the other deposits, and although *Reinschia* are plentiful the proportion of gelose is too low (0·012 to 0·024 per cent. maximum) for the coal to be considered algic. The thalli of *Reinschia* are strongly contracted and often folded; the gelose is greatly channelled and injected with a brown jelly, micrococcoids being also present. There are 2,080 thalli per cubic millimetre, and 26 rows in a vertical depth of 1 millimetre; 78 per cent. of the thalli are young, 20 per cent. being extremely so, and 22 per cent. are old, the majority of these being medium; a few thalli are gummy, and others are resinous.

The dry cellulose, derived from spores and pollen, forms 0·021 per cent. of the volume of the carbon, and there are 896 spores and 21,600 grains of pollen per 1 cubic millimetre. They are embedded in the abundant, dark-coloured fundamental brown jelly, concreted and broken up into a reticulated mass, strongly charged with bacteroids—small spherical, pale yellow bodies, singly or in couples. The moist vegetable *débris* is abundant, and mainly impregnated with bitumen by imbibition, some being injected as well.

Bitumen is the predominant substance in this coal. It is highly coloured, condensed like that of the kerosene shale of Capertree, and has penetrated the reticulated mass of humic jelly as a fine injection. It also fills sundry large horizontal fissures in the coal.

Four classes of yellow bodies are present—the thalli of *Reinschia australis*, the threads of *Bretonia*, spores and pollen, and sundry cuticular plates. The first-

named is the characteristic fossil of this coal, and proves its intimate connexion with the kerosene shale, which it most nearly resembles at the top of the Hartley shale, but is less charged with fusinified layers and introduced mineral matter, though, conversely, richer in pollen, spores and bitumen. The abundant precipitation of brown gelatinous matter embedded the spores, etc., and after solidification, became fissured in all directions, and subsequently injected with bitumen.

In microscopic structure, the coal resembles black Scotch cannel, and exhibits vertical cracks due to shrinkage, and greatly wrinkled veins of bitumen.

C. S.

ORIGIN OF COAL.

L'Origine de la Houille. By EUGÈNE BERTRAND. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 17-19.

Some cases of remarkable preservation noticed in certain coals cut into thin plates led the author to apply vegetable anatomy to the examination of coals generally; and acquired the facts which introduced great modifications into his comprehension of the carbonaceous rocks.

Algæ coals were formed by the accumulation of small plants, similar to those which now flourish on the surface of lakes and ponds. The substance that gave these coals their distinguishing characteristics is gelose, a matter rich in pectic products, which acted as a retaining body of certain hydrocarbons; and, although gelose is the predominating substance in algæ coals, it was introduced into them quite accidentally, having been deposited in a brown humic jelly which is present in all coals. Boghead is an algæ coal, and cannel coal also contains algæ; but in the latter case the gelosic matter of the algæ is no longer the predominating substance. The three wellknown bog-head minerals, that of Autun in France, torbanite, and the kerosene shale of Australia, are all algæ coals.

The humic coals, which are the most simple of any, are those formed of brown jelly, without the intervention of vegetable organisms or accidental substances; and the theoretical importance of these coals is very great, for they show the conditions necessary for the formation of Carboniferous rocks, freed from all the secondary or accidental causes which generally mask them. Just as the algæ coals are known in industry, so also are the humic coals, being the bituminous shales. The brown oil-shale of Broxburn is a typical humic coal; but when humic coals are sufficiently poor in mineral matters they assume the appearance of an ordinary coal. The absence of algæ was sufficient for a coal to be humic instead of gelosic, in the former of which cases the bitumen was retained entirely by the brown jelly; and the distillation of a humic coal will give quite different results from those afforded by the distillation of a bog-head.

The examples of simple coals teach one to understand those more complex; and the humic coals familiarize us with the notion of amorphous coals, formed without the direct intervention of vegetable substances, while they also afford an elementary notion of the conditions necessary for forming Carboniferous rocks. The examples mentioned show how slight was the cause which determined the specific characteristics of a coal—excrementitious matters here, gelose there, and pollen or small *débris* elsewhere; but these conditions suffice for perfectly determining different methods of enrichment by greatly modifying the capacity for retaining bitumen and completely changing their mode of localization, these facts being intimately connected with the formation of coal. J. W. P.

NORMAL AND REVERSED FAULTS.

Failles normales et inverses. *By* H. Forir. *Revue Universelle des Mines, etc.*, 1897, *series* 3, *vol. xl.*, *pages* 235-243 *and* 333-340, *with* 13 *illustrations in text.*

This article consists of a review of the following papers:—"Die Ueberschiebungen des Westfälischen Steinkohlengebirges," by Dr. Leo Cremer;* "Die Gebirgsstörungen im Steinkohlengebiete des Wurmreviers," by Mr. Franz Büttgenbach;† "Die Cremersche Theorie betr. die Ueberschiebungen des Westfälischen Steinkohlengebirges," by Mr. G. Köhler;‡ and "Ueber Verschiebungen und Sprünge im Wurmrevier," by Mr. Franz Büttgenbach. §

These papers refer chiefly to the faulting that the coal-basins of Westphalia and Wurm have undergone. In the former, the general strike of the strata is south-west to north-east, the beds being flexured so as to form an alternation of troughs and saddles; they are crossed by two main series of faults, one set being steeply inclined, striking north-west to south-east, and having normal throw. The others coincide markedly both in direction and dip with the strata, and are reversed or overthrust faults, hading at all angles. These reversed faults show the great peculiarity, which is illustrated by numerous examples, of not either dipping or striking in approximately straight lines, but of also being flexured in the same way as the strata themselves, so that these faults form saddles in the anticlines and troughs in the synclines of the strata. Their angle with the direction of stratification is always small, between 12 and 18 degrees, averaging 15 degrees, and their importance is very variable; some extend for a very short distance and have but a slight amount of throw, others have throws of 1,000, 2,000, and up to 3,000 feet, and one fault, the Sutan fault, has been traced for over 17 miles. The curvatures of these reversed faults are clearly shown in a number of sections.

In the Wurm coal-basin, the general strike of the bedding is north-east to south-west, with slight regular undulations, the strata being steeply inclined only at the south-eastern extremity of the basin, which is cut off at its north-eastern end by an immense normal fault (the Sandgemand) of unknown throw. There are numerous normal faults running perpendicularly to the strike, which are generally of considerable width, and are filled in part with a breccia composed of fragments of the walls and of other rocks, among which are Tertiary and Quaternary pebbles, and in part with vein-minerals. There are also numerous reversed faults, distinguished from the former by being very narrow, and by their general north-east to south-west strike, which approaches closely to that of the beds without coinciding with it. Their dip is usually to the south and varies between 30 and 60 degrees, the amount of overthrust increasing with their angle with the vertical. Two of these faults show the remarkable flexures that have been described in the Westphalian coal-field.

The explanations of these phenomena given by the various authors, are somewhat divergent. Mr. Cremer holds that the reverse faults were already in existence before the folding of the strata commenced, and that they were affected by the folding movement in precisely the same way as the strata themselves. He supposes that the first result of lateral pressure upon the flat-lying beds will have been the production of inverse faults lying at low angles of inclination, and that a continuation of this same lateral thrust induced the folding of the strata together with that of the already formed faults. Mr. Buttgenbach's views are in part

* *Glückauf*, 1894, pages 1089, 1107, 1125, and 1150. † *Ibid.*, pages 1549, and 1569.
‡ *Ibid.*, pages 1615, and 1654. § *Zeitschrift für praktische Geologie*, 1895, pages 133-137.

similar, and he shows that very flat-lying faults are much more liable to deformation than steeply dipping on vertical ones under the same lateral thrust. Mr. Köhler considers that these faults are due to shears produced by plication, so that flexure would have preceded faulting, but admits that a continuation of the horizontal thrust may have contorted the faults thus produced.

The author agrees upon the whole with Mr. Cremer's views, and holds that they do not exclude the theories of Messrs. Heim and Köhler, but may be perfectly well brought into agreement with them. H. L.

CLASSIFICATION OF DEPOSITS OF ECONOMIC MINERALS.

Denomination et Classification des Gisements de Minéraux utiles. By HANNS HŒFER. *Revue Universelle des Mines, etc.*, 1897, *series* 3, *vol. xxxviii., pages* 79-89.

The following table shows the system of classification proposed by the author :—

In Relation to the surrounding Rock.		Origin of the Deposit.	Size.	Form of the Deposit.			
				Flat.	Lenticular.	Irregular or Equal in all Directions.	Linear.
The deposit may be	Contemporaneous	Sedimentary	Large	Bed	Stratiform mass	Stratiform bunch	Stratiform column, straight „ pipe, contorted
			Small	Seam	Lenticule	Stratiform pocket	Stratiform thread
		Eruptive	Large	Eruptive sheet	Eruptive mass	Eruptive bunch	Eruptive column or pipe
			Small	Eruptive film	Eruptive lenticule	Eruptive pocket	Eruptive thread
	Posterior	Filling cavities	Large	Vein	Veinlike mass	Veinlike bunch	Veinlike column or pipe
			Small	String	Veinlike lenticule	Veinlike pocket	Veinlike thread
		Metamorphic	Large	Metamorphic bed	Metamorphic mass	Metamorphic bunch	Metamorphic column or pipe
			Small	Metamorphic seam	Metamorphic lenticule	Metamorphic pocket	Metamorphic thread

H. L.

LOUVAIN COAL-MEASURE MUSEUM, BELGIUM.

Musée géologique des Bassins houillers Belges. Préface by PROF. R. ZEILLER *to catalogue of objects sent to the Brussels Exhibition of* 1897.

Although the services rendered to industry by physics and chemistry are never called in question, the same importance is not generally attached to those which geology and palæontology are capable of rendering the mining art ; and the miner generally considers himself capable of determining the order of seams that he works, and of tracing them again from one side to the other of disturbances that may have dislocated them. Cases have, however, occurred in which the mere

application of mining art to determining the continuation of a deposit has only led to disappointment, and in which the assistance of geology or palæontology was found necessary for attaining the desired result. More than one instance of this may be found in the history of coal-mining; and it is astonishing that the immediate utility of studying each deposit in detail, and of methodically collecting the fossils it contains, has not been understood long ago, and that investigations of this nature have not been more largely undertaken by coal-owners.

So early as 1856, Prof. H. B. Geinitz showed, by a study of the coal-deposits in Saxony, that the flora gradually changed from one level to another, and that its modifications might be employed to determine the age of each group of coal-seams. In 1877, Mr. Grand'Eury, applying the same method, first to the coal-fields in the centre and south of France, and afterwards to other coal-formations in Europe and North America, laid down the bases of a general classification founded on a study of fossil plants. In 1888, the portion in France of the Franco-Belgian coal-field formed the object of a detailed study, which permitted of determining the palæological characteristics of the various groups of seams, and of fixing the exact age of each; and the conclusions thus arrived at were confirmed by the thorough concordance of the observations subsequently made by Dr. Leo Cremer in the Ruhr coal-field, by Mr. R. Kidston in Great Britain, and by Mr. David White in the United States of America, the various coal-fields being, wholly or partially, contemporaneous with that in the north of France, and having presented the same groupings of species succeeding one another in the same order.

The utility of palæo-botanical research, and the confidence that may be placed in its conclusions, have also been confirmed by important practical results. At the Grand'Combe colliery in the Gard coal-field, especially, a study of the flora in the various group of seams on either side of a large fault permitted of determining the relative age of these groups and the direction in which they had been displaced, and also of proving that the system to the roof of the fault, far from being the more recent as had been supposed from stratigraphical observations, was really the more ancient; and a bore-hole subsequently put down to the foot-wall of the fault actually passed through this system, represented by thick coal-seams, at a depth of about 2,500 feet (750 metres).

Quite recently, in the Saint-Eloy coal-field of France, the discovery of a coal-seam, $4\frac{1}{2}$ feet (1·4 metres) thick, at the depth of 950 feet (290 metres), proved the correctness of Mr. Grand'Eury's inferences deduced from his palæo-botanical observations, while rewarding the explorers who had trusted them. Moreover, Messrs. Grand'Eury and Fayol have formed important conclusions with respect to the method of coal-formation from a detailed study of the Saint-Etienne and Commentry seams, examined as to their strike, their mutual relations, their varying thickness, nature, constitution, etc.; and in this case, to the scientific interest was added a practical one, viz., an exact knowledge of the method in which a coal-seam was formed, it being manifestly of interest to the miner to know whether he can be sure of again finding, at all points in his field of working, the same seams, under the same circumstances, separated by the same thicknesses of rock, and also whether the disturbances noticed in one of them necessarily affect all the others, or whether he must expect the seams to approach or recede from one another, or perhaps unite, and so on.

During the last 20 years, knowledge of coal-formation has made great progress, by which mine-working has benefited on more than one occasion; but, whatever be the general result acquired, it is evident that in each coal-field a detailed study must first be made on the spot, and its results collated.

As regards Belgium, the results of stratigraphical study by Messrs. Cornet, A. Briart and others are widely known and appreciated; and Mr. Sauveur has left drawings of the chief species observed by him in the coal-measure flora of the country. It was felt, however, by the Rev. G. Schmitz, that such general studies should be completed by more thorough and detailed local investigations, and especially by as complete palæontological observations as possible; and this is what led to his undertaking a work the importance of which was made evident by the collections shown by him at the Brussels Exhibition. Convinced of the advantages which mine-working on the one hand, and geological and palæontological science on the other, may derive from a detailed study of the coal-seams, he appealed to all the colliery managers in Belgium for their co-operation in forming a methodical collection of specimens—chiefly fossil plants—from every deposit and seam, with a view to constitute a special coal-measure museum which, if its founder be well supported, must soon afford the most valuable materials for comprehensive study. J. W. P.

MINERAL PRODUCTS OF CORSICA.

Étude sur les Gîtes minéraux de la Corse. By — NENTIEN. *Annales des Mines*, 1897, *series* 9, *vol. xii.*, *pages* 231-296, *with* 5 *illustrations in text and* 1 *plate.*

Fuel.—The only mineral fuel thus far known in Corsica is an anthracitic coal worked at Osani, on the western coast. The area of the concession, granted in June, 1889, is about 968 acres (392 hectares). Here the Coal-measures, dipping 30 to 50 degrees west-south-west, and overlying pre-Cambrian schists and quartzites, are cut by igneous dykes and sills (orthophyre and petrosiliceous porphyry). They are overlain by conglomerates and sandstones varying in thickness from 200 to 450 feet. In the one coal-seam so far proved, only exploration work has been carried out. The seam is nowhere more than 5 feet thick, and yields a coal very anthracitic in character, burning with a short flame. The percentage of ash does not appear to exceed 12. Some insignificant deposits of coal have been proved on the shores of the Bay of Lignaggia, south-west of Murato; also north of the Col of Bocca Croce, on the slope to the Gulf of Girolata; and near Galeria, Argentella, Poggio d'Oletta, etc.

Iron.—The one iron-mine in the island, that of Farinole (area of concession 2,690 acres) has been abandoned for many years, nor was it ever seriously worked. The ore is a magnetic oxide of iron, containing a slight percentage of chrome-iron. It occurs in lenticles in two hills of pre-Silurian serpentine.

Manganese.—No mining-concession for the ores of this metal has yet been applied for in Corsica. Nevertheless, manganiferous deposits occur in several localities. Those proved north-east of Cervione and near Bisinchi are too poor to repay working, and with the others the author is personally unacquainted.

Chrome Iron-ore is nowhere sufficiently abundant to be of industrial importance.

Antimony.—Three mines, those of Luri Castello, Meria, and Ersa, are at work. The combined area of the properties is about 3,350 acres, and the average annual production since 1890 has exceeded 1,500 tons of marketable ore. The antimony occurs as a sulphide (stibnite) in veins cutting through hornblende and sericite schists, and these veins are supposed to be older than the pre-Silurian serpentines. The strike of the principal veins is east and west; sometimes they are crossed nearly at right angles by other veins; but these cross-veins, though fairly rich, are less continuous. The gangue is quartzose in character, and has a peculiar green colouration which serves as a good indicator at the outcrop. The vein is

generally richest near the foot-wall, which is always better marked off from the country-rock than the hanging-wall. The best ore yields 40 to 55 per cent. of metal, and is sorted on the spot ; but there is a good deal of poorer stuff, the sorting of which is seriously hampered by the presence of heavy pyrites.

Arsenic.—Realgar and orpiment are found in very small veins in the *schistes lustrés*, a mile or so north-east of Porta d'Ampugnani and near Matra. The author does not think that the deposits could ever repay the trouble of working them.

Lead and Zinc.—Three lead-mining concessions have been granted in Corsica, those of Argentella, Monticello, and Prato. Their combined areas amount to about 8,520 acres. The Prato mine has never been seriously worked, and the few excavations made at the junction of the *schistes lustrés* with the Miocene sedimentaries only reveal a small quantity of pyrites with a few traces of argentiferous galena. The same statement applies to the Monticello mine. At Argentella, a vein of galena in granulitic granite, varying in thickness from a few inches to 3 feet or more, has been worked perseveringly. The ore has large crystalline faces, contains but little silver, and is associated with blende, pyrites and chalcopyrite. In places, the granulite country is impregnated with galena in patches and veinlets for a breadth of 13 to 17 feet. The percentage of rich ore is so small that the whole of the vein-stuff is crushed without preliminary sorting. A fine plant was put down for dealing with the ore, but the yield was so small that for the past 10 years the working of the deposits at this level has been abandoned. Lower down, at Vallesalle, and at Bocca Bassa on the sea-coast, quartz-veins, mineralized principally with chalcopyrite, have been proved in the pre-Carboniferous schists.

Tartagina, near Castifao (area of concession about 2,660 acres), is another lead-mine now abandoned.

Copper.—Exploration work was at one time carried out at the St. Augustine mine (area of concession about 3,800 acres) in the lenticular deposits of chalcopyrite at the contact of the serpentine and the Eocene shales. The workings were given up 15 years ago.

The Ponte Leccia mine (area of concession about 4,170 acres) was worked more perseveringly. Some masses of chalcopyrite and phillipsite were found by small headings driven into the hillside ; malachite and azurite occurred near the outcrops. The whole region is traversed by diabase-dykes which greatly interfere with exploration work.

On the eastern coast, some work has been done at the Linguizetta mine (area of concession about 1,700 acres), but here, too, the ore has failed to appear in paying quantities. Copper ores have been proved at other localities in the island, as, for instance, at the Col of San Quilica, Casaluna, Sermano, Ficicchia, and Vezzani.

Pyrites was at one time worked at the Cardo and Lancone mines. The ore does not occur in veins or beds, but impregnates hornblende-schists. At Cardo, the smelting-works, with washing and precipitating-tanks for the copper (usually amounting to less than 4 per cent. in the ore) was shut down 10 years ago.

Quarries, etc.—Granite has been worked since Roman times. The author also mentions beautiful diallage and bastite-serpentines, and pink and green syenites, as furnishing good ornamental material and occurring in easily accessible localities. Various kinds of marble are now worked in Corsica, and the more fissile varieties of hornblende-schist yield heavy roofing-slate. Besides the *cipolino* marbles, Liassic and Eocene limestones are largely burnt for lime. Asbestos occurs in the north-east of the island ; gypsum, not in paying quantities, at the Col of San Quilico. Brick-earths and pottery-clays are scarce, and of poor quality.

Mineral Springs. The ferruginous-bicarbonated waters are classified by the author as of the Oregga type. They occur in a score or more localities along a line sensibly parallel to the ridge of San Pedrone, probably a line of fault.

Sulphuretted-alkaline springs are disseminated irregularly over the entire granitic region of the island. Most of these springs are hot, and the hot springs without exception well forth from the granite; while the less numerous cold springs (the original character of which appears to have been altered by mixture with surface-waters or by chemical reactions in the rocks traversed by them) come out of the *schistes lustrés*.

The paper is followed by a complete list of the mineral localities and a map on which they are marked. L. L. B.

BROWN COALS, IRON-ORES, AND OTHER MINERALS ON THE NORTHERN SLOPE OF THE SIEBENGEBIRGE, RHENISH PRUSSIA.

Geologische Darstellung des Nordabfalles des Siebengebirges. By E. Kaiser. *Verhandlungen des naturhistorischen Vereins der preussischen Rheinlande, Westfalens, und Osnabrück,* 1897, *vol. liv., pages* 78 *to* 204, *with figures in the text and* 1 *plate.*

Of this very careful and complete geological study of the district, accompanied by a full bibliography and a geological map, upon which are marked all the mines or collieries now or formerly at work, it is only possible, in an abstract, to give the merest outline.

The oldest rocks in the area are the Lower and Middle Devonian grauwackés, sandstones and shales. Among these occur in irregular deposits clay ironstone, brown hæmatite and spharosiderite. Efforts have been made to work these ores at several localities, especially near Römlinghoven and Muschmuhle, but working has proved unprofitable; firstly, because the deposits vary so much in thickness, and, secondly, because they show no continuity of strike or dip.

Metalliferous veins (zinc, lead, etc.), occur also in the Devonian, but for the description of these and the mines which work them, the author refers to the recent treatises of Mr. E. Buff (Bonn, 1882), and Mr. C. Heusler (Bonn, 1897). He draws, however, especial attention to the Altgluck mine, near Bennerscheid, where there is a fine example of a vein with conglomeratic, that is, clastic infilling, which cuts across both the country-rock and the lead and zinc-ore deposit. This cross-vein conglomerate is a mass of fragments of the country-rock, quartz, sandstone, brown coal, lignite, and metalliferous ores and gangue, and it has faulted the true metalliferous vein; nor is this occurrence an isolated example.

Immediately above the Devonian comes a great series of Tertiary strata, supposed to be of Upper Oligocene or Lower Miocene age. They constitute the south-eastern portion of the Lower Rhenish brown coal-field, and are divided into three groups, which may be briefly defined as follows, in ascending order: —

(1) Clays, white to greyish-blue, here and there red to reddish-brown through the presence of iron. They are largely worked for bricks, tiles, fire-clay, etc. Quartzites, lignites, sandstones, and conglomerates, with opaline or chalcedonic cement.

(2) Trachytic tuffs, horizontally bedded, with opaline cementing material, and sometimes overlain by sheets of the basalt which has welled up through them. In places, the percentage of iron in the tuffs is so great that nodules of clay-ironstone have separated out from them. The fine-grained, strongly pumiceous beds in the

tuffs, in those localities where there are few volcanic bombs of any great size, are quarried for building ovens, as in the Lauterbachthal. Other beds are quarried for ordinary building-stone.

(3) Clays, lignites and paper-coals, alum-clays, sands, and clay-ironstones. This third group is overlain by drift, loess and alluvial deposits.

Of the many lignite mines which up to 1866 and 1876 were in full work, only one is now being worked—the Horn colliery, between Stiefeldorferhohn and Höhnerhof. Previous to 1866, the industry was prosperous, but the competition of American and Russian petroleum rendered profitless the labour of extracting paraffin from the paper-coals; and on the other hand, the lignites were no longer used in the manufacture of alum when the potash-alum from the chemical works drove other varieties off the market.

The authors who have dealt with the conditions of mining, etc., of the lignites are chiefly Messrs. H. Bleibtren, H. von Dechen, and C. F. Zincken. They gave many details, vertical sections, results of borings, etc., but no general view of the succession. This the present author seeks to do: thus in the Hardt, the ridge which divides the Rhine Valley from the Lauterbacthal, he gives the following succession in group 3:—

(f) Alternations of lignite, clay (frequently containing clay-ironstone) and sand.
(e) Alum clays (so-called).
(d) Main lignite-seam.
(a) Clays with intercalations of lignite and sand.

In the neighbourhood of Rott, beds b and c come in, b being paper-coal or dyssodil, very impure at times, and replaced frequently by kieselguhr, polishing slate, semi-opal or hornstone, and c, clay. Here, too, the clays a are associated with ironstone, while the clays f pass here and there into trachyte-tuff.

The clay-ironstones when viewed over a large area are very irregular in occurrence: at one spot there may be as many as thirty bands in a thickness of 25 feet or less; at another spot, in 35 feet of strata there will be only three or four bands of ironstone. These bands vary in thickness from 7 to 20 inches, and the ores occurs also in the form of spheroidal and reniform nodules. Pyrites also has been found in sufficient quantity to repay working, in former years, below the paper-coals.

The paper-coals of Rott are considered by the author to correspond to one of the lower lignite-seams of the Hardt. They are highly bituminous, and contain a very large percentage of ash. In addition to the microscopic vegetable particles of which they are chiefly composed, they include a number of larger plant and animal-remains, also masses of diatomaceous earth, tripoli and kieselguhr. Sometimes the tests of the diatoms have a siliceous, agate-like infilling, and by their coalescence the loose kieselguhr passes gradually into hornstone and semi-opal.

Turning now to the lignites, the author distinguishes in them three varieties: (1) the lignitic brown coal, (2) the earthy brown coal, and (3) the pyritiferous brown coal (used in the process of extraction of alum).

The first-named shows clearly the structure of the conifers and other forest trees from which it was derived; some of the trunks are found in an upright position in the seams, but most lie flat, squashed by the pressure of the superincumbent strata.

The earthy coal, consists of completely macerated woody particles, mixed with a large proportion of impurities which make its ash-percentage a very high one.

The third variety is partly lignitic, partly earthy in character, but as it becomes more and more pyritiferous and argillaceous it passes gradually into the (so-called) alum-clays.

It is pointed out that the main lignite-seam only repays working where the lignitic variety occurs in great thickness, as at the Satisfaction pit, near Uthweiler, where the coal is 14¼ feet thick. Here it may be observed that the basalt, which was erupted at a period later than the deposition of the lignite has altered some of it in this pit into bituminous coal. In the Horn colliery, previously mentioned as the only one in the district still at work, the main seam attains a thickness of 27½ feet. It is reached by a shaft at a depth of 30 feet, the floor of the seam being about 57 feet below bank, and beyond this level a boring has been put down to 182 feet, passing first through 32½ feet of trachyte-tuff, and then through blue and bluish-grey sandy clays (95 feet), in which it was stopped. Of this coal, the author gives the following analysis (made for the colliery owners by Dr. R. Fresenius); carbon 60·14 per cent., hydrogen 5·02 per cent., oxygen and nitrogen 20·85 per cent., sulphur 3·11 per cent., and ash 10·88 per cent.

Above the main lignite-seam occur at many localities highly bituminous clays or clayey brown coals, which on accounnt of their thorough impregnation with pyrites in a state of extremely fine division have attracted much attention, and being used in the extraction of alum have become known as alum-clays. Their thickness varies from 2 to 8 feet.

Above these again are plastic clays, with lignites and sands. In the clays, just as in those previously described beneath the paper-coals are numerous bands and nodules of ironstone, occurring at two distinct horizons. The lignites are much the same as those of the main-seam, but they do not extend continuously over so large an area as that seam: their greatest thickness hardly reaches 40 inches.

The author describes with great fulness and precision the eruptive rocks, and the diluvial and alluvial deposits, but as they are of no industrial importance they need not be further referred to here. L. L. B.

GEOLOGY OF LESBOS, LEMNOS AND THASOS.

Études géologiques sur la Mer Égée: la Géologie des Iles de Mételin (Lesbos), Lemnos et Thasos. By L. DE LAUNAY. *Annales des Mines*, 1898, *series* 9, *vol. xiii., pages* 157 *to* 316, *with* 10 *figures in text and* 4 *plates.*

The author made a careful study of the three islands, which are under Turkish rule, in the years 1887 and 1894, and he is practically the first observer who has worked out their geology.

Lesbos or Mitylene is roughly divisible into two regions: that east of the Gulf of Kalloni is made up of Primary rocks (metamorphic schists and marbles) and serpentines; while the western area is overspread by Tertiary eruptive rocks, such as rhyolites, trachytes, obsidians and basalts, together with stratified breccias and conglomerates containing silicified wood.

In this island there is little mineral wealth of any consequence. The only deposits worked are those of alum, which is here manifestly an alteration-product of the andesites, at Stipsis between Agra and Mesotopos, north of Parakila, and near Chydera. Antimoniferous quartz-veins occur in the mica-schists north of Skopolo; chrome iron-ore is found in masses, associated with chalcedony and

chrysotile, in the serpentines between Mount Olympos and Keramia ; native copper east of Molyero, between Parakila and Vatussa, and north of Mistegna. There are also deposits of ferruginous scoriæ west of Potamos-Plumari, and at Asomatos near Mesotopos. Thermal springs containing chlorides of sodium, potassium, lithium, magnesium and calcium occur at various localities, especially along the coasts of the island. One of these, the Polichnitos spring, welling forth at a temperature of 185° Fahr. from highly siliceous obsidian, is remarkably active and abundant. Further, the author mentions among the Tertiary beds on the coast north of Mount Orthymnos, bands of bituminous limestone with intercalated seams of lignite.

Coming now to the island of Lemnos, the author draws attention to the great spread of Eocene sandstones and shales, with a few conglomerates, dark brown to dark green in colour, rich in badly-preserved plant-remains. These may be correlated with the similar early Tertiary rocks found all around the coasts of the Ægean Sea, and its islands—in Euboea, Peloponnesus, Crete, Rhodes, etc. The sedimentaries are broken through by dykes and vast sheets of dacite, trachy-andesite, augite-andesite and quartz-andesite. The author noted an unexpected similarity of appearance and denudation between the Lemnos Tertiaries and the South African Karoo, and attributes to both an estuarine origin.

No metalliferous ore-deposits worthy of mention have been traced on this island, On Imbros, a closely neighbouring and geologically connected island, a British company obtained a concession for working the lignites in 1875, and started operations there. At Lidja, in the west of Lemnos, north of Mount St. Elias, an abundant thermal spring wells out at the contact between argillaceous shales and eruptive andesites. At Cape Purnia, a very hard *lumachello* (consisting of broken up marine shells and sand-grains) has been quarried for building stone ever since ancient times.

The island of Thasos is almost entirely made up of gneiss, mica-schists and hornblende rocks, among which are intercalated masses of marble, and there are a few conglomerates, probably of recent origin, on the western coast. The rocks form a great north-west to south-east anticlinal, along whose northern edge runs a big fault—the beds on the southern side are nearly horizontal, while on the northern side they dip almost vertical.

The coarse-grained white marble was worked by the ancient Greeks and Romans for statuary, and the gold-mines were described by Herodotus. The author had no opportunity of testing the accuracy of that historian's statements, but in the west of the island he found undoubted traces of ancient copper-mines, with the old waste-heaps still *in situ*. The metalliferous deposits appears to range along a north-and-south line, and the village of Kakirashi is the centre of what was formerly a great mining district. The country-rock is an alternation of mica-schists and marble, the former predominating ; but the deposits appear to have been worked most actively in the marble where the ore was most concentrated, the calcareous element having doubtless some chemical influence on the process of mineralization. The beds dip rather sharply, as much as 50 degrees in the neighbourhood of Sotiro. The ore is chiefly argentiferous antimony fahlore, assaying 28·37 per cent. of metallic copper, 24·2 per cent. of antimony, and 0·096 per cent. of silver. It is associated with baryta and spathose iron-ore, constituting an assemblage which, as the author points out, "in any other country but Turkey, where there would be some security for mining property, would be well worthy of attention." Yet Thasos, it appears, belongs to the Khedive, and in 1887 his local agent requested an engineer to make a preliminary investigation among the metal-

liferous deposits, but no further steps were taken, as it was feared that the necessary exploration-work would prove too costly.

The author then gives a very useful summary of the work done by other geologists on the islands and coasts of the northern portion of the Ægean Sea, showing how far the geology of these may be correlated with that of the three islands described by him. An Appendix by Prof. Fliche on the fossil wood of Lesbos, and a carefully compiled bibliography, complete a most instructive monograph. L. L. B.

MINERAL DEPOSITS OF THE SOUTH-WESTERN PORTION OF THE ISLAND OF SARDINIA.

Das Vorkommen nutzbarer Mineralien in dem Süd-westlichen Theile der Insel Sardinien. By Bergassessor Stockfleth. *Verhandlungen des Naturhistorischen Vereins der preussischen Rheinlande, Westfalens, und Osnabrück*, 1897, *vol. liv., pages* 66 *to* 77.

As far back in the world's history as the times when the Phœnician navigators scoured the Mediterranean was Sardinia known for its rich silver and lead-deposits. These were afterwards worked by the Carthaginians when they gained possession of the island, and then by the ancient Romans, whose pits and slag-heaps are traced to this day. But it was reserved to the latter portion of the nineteenth century to make known the equally rich calamine-deposits, and the extraordinarily pure and abundant iron-ores. The discovery of deposits of iron-ore in the south-western districts of the island as recently as 1896, awakened great interest among capitalists and mining experts in Germany, and the author was instructed to make a searching enquiry on the spot.

Like the rest of Sardinia, the south-western portion is a mountainous country, cut by valleys whose formation is largely due to the erosive action of water. By centuries of disforestation the country has been converted from fertile, arable land into barren, treeless wastes. The rocks are mainly Silurian, broken through by great masses of granite. In the valley which runs past Iglesias to the western coast are Tertiary deposits with workable seams of lignite but it is mostly filled with drift and alluvial deposits of recent or subrecent formation.

The Silurian strata consist of an irregular succession of red, grey, bluish-grey to blue, more or less compact slates, sometimes highly calcareous, sometimes rich in mica ; of fine-grained argillaceous sandstones, which frequently pass into red, violet, and greenish-grey sandy shales ; of coarse-grained quartz-conglomerate and pure quartzite ; of massive limestones, dolomites and flaggy limestones. Doubtless the formation of the metalliferous ores has been in many cases favoured by the uprise of the granites, at the contact of which with the Silurian slates and limestones appear more especially the remarkably pure and abundant hæmatites.

The ore-deposits occur as veins, seams or reefs, and masses or beds. They comprize :—

(1) *Argentiferous galena*, occurring in places as veins, elsewhere as massive deposits. These ores are confined to the Silurian slates and limestones. The veins (*e.g.*, Monte Vecchio) undoubtedly owe their origin to the fissures caused by the uprise of great masses of granite subsequent to the deposition of the stratified rocks ; whereas the massive deposits (*e.g.*, Monte Poni, Giovanni) are due to an earlier process of infilling in the great belt of ore-bearing limestones. The ore lies

often many feet thick, consisting of massive galena, with a percentage of silver varying from 0·04 to 0·18. On the whole, the vein-galena may be regarded as rich in silver, whilst the massive galena is poor.

(2) *Zinc blende.*—This ore is sometimes found associated in a very subordinate way with the massive galena. It is true that lately, near the hamlet of Nuxis, 10 miles south of Siliqua, a vein in the Silurian slates and limestones has been struck which yields nearly equal quantities of blende and galena, the two ores being ultimately commingled. An experimental drift has revealed a thickness of 13 feet of ore.

(3) *Calamine* occurs everywhere in masses, which are essentially the infilling of irregular hollows in the limestones of the great ore-bearing belt. They appear close to the junction between these limestones and the clay-slates. The most important mines are those of Buggerw and Malfidano on the western coast north-west of Iglesias, which have only been started within the last 30 years. Calamine-deposits are also found in close association with the galena-masses of Monte Poni and Giovanni.

(4) The *iron-ores*, although so widely spread and massive, have remained till quite lately practically unknown. It is true that the magnetite of Leone, near Capoterra, has been worked for a time on a small scale. But to this must be added now the great newly-discovered deposits of hæmatite at Sissini de Montis, Bacchixeddu, Chia-Malfatano, and the magnetite-bed of Is Crucurris. The ores at the outcrop are astonishingly rich and free from impurities. The hæmatite of Sissini de Montis occurs east of the well-made high road from Siliqua to Santadi, about 3 miles north of the hamlet of Nuxis: here a broad ridge rising some 650 feet above the valley-floor, is bordered on its eastern slope by a sheet of granite: it is at the contact between the Silurian slates and the granite that the hæmatite occurs in great masses, continuing westwards in a network of fissure-veins. The author was able to trace the connexion between these and the Migas-Sermentos (Nuxis) zinc-blende and galena veins. He believes that in reality such of the iron-ore as is not in immediate contact with the granite-zone, forms a sort of gossan to rich zinc and lead-ores.

A few miles south-east of Nuxis occurs the ore-deposit of Bacchixeddu: here, over a length of 1 mile or more the blocks of hæmatite stand out like walls amid the weathered granite and Silurian limestone, while rounded boulders of them are spread over the hill slopes or form the cliff-talus. Very similar is the occurrence between Point Chia and Cape Malfatano, the southernmost headland of Sardinia. All these hæmatites contain on an average 67 to 69 per cent. of metallic iron.

The magnetite of Is Crucurris, some 3 miles south-west of Cagliari, is interbedded with the Silurian slates in the form of a deposit about 20 feet thick. It is quite metallic in character, and contains on an average 68 per cent. of iron.

(5) *Lignite* occurs in seams in the small Tertiary basin of Gonnesas, south-west of Iglesias. For several years, ten seams, each averaging 20 inches in thickness, have been worked with good results: they yield the only available mineral fuel in the whole island. The calorific capacity, compared with that of the imported British coal is as 1 : 1·7.

In addition to the above-described minerals, the author noted the occurrence of copper and iron pyrites, fahlores, antimony glance, cerussite, anglesite, malachite, etc., but these ores are not apparently in sufficient quantity to be of industrial consequence. The gangue of the metalliferous veins is frequently made up of quartz, calcspar, and secondarily of heavy spar and fluor. L. L. B.

TAGIL AND GOROBLAGODAT MINING DISTRICTS.

Le Chemin de Fer de l'Oural dans les Limites des Districts miniers de Tagil et de Goroblagodat. By TH. TSCHERNYSCHEW. *Congrès Géologique International: Guide des Excursions, No. ix., pages* 1 *to* 23, *with* 8 *figures in text and* 6 *plates*, 1897.

Taking a broad survey of the area described, we find that its eastern portion, on the Siberian slope of the Urals, is chiefly a region of massive eruptive rocks (porphyries, etc.), tuffs, and breccias, among which metamorphic schists and limestones play only a secondary part. The western portion is essentially a mountain-range of crystalline rocks: granites, syenites, gabbros, serpentines, etc., with Lower Devonian marbles, slates, and limestones. The whole of this area is extraordinarily rich in metalliferous ores; besides other mines to which reference will be presently made, gold and platinum-deposits occur in association with chrome iron-ore, in serpentinized diallage-rocks and peridotites, and gold in quartz-veins in metamorphic schists; there are also rich auriferous and platiniferous sands in the Martian, Chaúsh, and Iss river-basins, evidently derived from the preceding.

Nijni-Tagilsk, the most considerable mining locality in the Urals, is the property of the Demidoff family. North-west of the ironworks rises the Vyssokaia hill: it consists chiefly of quartzless porphyries, with which are associated rich deposits of magnetite. The orthoclase-rocks decompose into thick beds of whitish and pinkish clay, in which are scattered blocks of magnetite: the latter is often seen to pass into martite. The iron got here is very pure, and much valued for metallurgical purposes.

The author considers that the mutual relations of the metalliferous masses and the accompanying rocks in the Vyssokaia hill point to a common and simultaneous origin: the magnetite was separated out of the same magma as the orthoclase-rocks.

South of Vyssokaia is the Mednorudiansk mine, where, between two bands of limestone, occurs a cupriferous deposit. Here great masses of malachite have been found, and copper oxides in the ochreous clays, which become richer at the junction with the limestone. It is probable that at the contact of the latter with the metalliferous deposit a chemical reaction takes place; the limestone is dissolved, leaving a clayey residue, and the copper brought thither by waters percolating through the calcareous rocks is thrown down. This mine is remarkable for the combined occurrence of magnetite, spathose iron-ore, limonite, and copper-ores.

North of the Tagil ironworks we come first to the Lebiaia magnetite-mine, where the occurrence is perfectly analogous to that of Vyssokaia. The workings here, however, are beset with the difficulty that there are many impurities disseminated in the ore (cupriferous clay, apatite, etc.). A few furlongs north-west of Lebiaia are the manganese mines. The ore-deposit has for its hanging-wall a crystalline limestone, and for foot-wall yellow, pinkish and violet slates. It occurs in nests, and there appears to be an intimate relationship between it and the Lower Devonian limestones.

Leaving the Demidoff estate, the author takes his readers to Kushwa, the ironworks forming the administrative centre of the Crown property of Goroblagodat. The Blagodat hill, not much more than 1 mile distant from Kushwa, rises to 1,154 feet above sea-level. Here, as at Vyssokaia, the rocks are mainly quartzless

porphyries of the keratophyre and orthophyre types. In both cases, too, they pass into garnetiferous epidotites and calcareous rocks, whose appearance coincides with the disappearance of the masses of magnetite. The rocks at Blagodat show signs of crushing, tearing, twisting, etc., evident traces of dynamo-metamorphism. The ores are "blue" and "red." The deeper the workings are carried in, the more does the red ore give place to blue. The latter is largely speckled with green chlorite. There are many large druses, wherein besides magnetite crystals are growths of brownish-red garnet-crystals. The ore-deposits vary much in form—sometimes they are veins, which pass gradually into an orthoclase rock while the magnetite disappears, sometimes they are in nests or shapeless masses.

The porphyries are distinctly bedded, as at Vyssokaïa, but the structure of the hill is complicated by two series of faults—the earlier longitudinal (parallel to the meridian and to the Blagodat ridge), and the later transverse. L. L. B.

MINERAL MINES IN THE SOUTHERN URALS.

Die Mineralgruben bei Kussa und Miass. By A. Arzruni. *Congrès Géologique International: Guide des Excursions, No. iv., pages* 1 *to* 25, *with* 2 *figures in text*, 1897.

The mineral deposits of the Southern Urals may be divided into two groups, both topographically and geologically. One group lies west of the main range, in the area of the metamorphic schists, or on the eastern boundary of the lowermost Devonian; the other lies east of the main range along a line of hills running parallel to it—the Ilmen hills, which are made up of granites and syenites.

The westernmost group is situated on the Shikhim hills. Here we find first the Paraskówie-Ievgeniev mine, opened in 1868; the rock here is chiefly a greenish-grey talc and chlorite-schist, with inclusions of hornblende, and the minerals are garnet, ilmenite (of the following composition:—11 $FeTiO_3$ + 17 $MgTiO_3$ + 1 $MnTiO_3$), magnetite, spinel, etc. The same minerals, together with apatite and tourmaline, occur in the Shikhimaskaia mine farther south. Vesuvian, associated with white or pinkish-white garnet, is a characteristic product of the Barbótovskaia Iáma mine.

North-east of the Shikhim hills are the Chuwash hills; here amid the Lower Devonian slates is a baryta-mine, first opened up in 1826, and worked then for brown iron-ore. The reported occurrence of celestine is not confirmed.

In thinly-bedded chlorite-schists among the crystalline limestones the Redikórtzev perowskite-mine was opened in 1878. The perowskite occurs in black crystals with a semi-metallic lustre, frequently showing "aetz-striations;" actinolite and byssolite are found here too.

Nearer the main range of the Urals are the Názem hills. The most recently worked mine among these is the Jeremeïer, opened up in 1888. It yielded garnet, magnetite, titanite, vesuvian, etc.

The author gives a long list of minerals from two other mines, but as these do not appear to have been worked for many years, there is no occasion to devote space to them in this abstract. About 1 mile north of one of them (the Nikoláie Maximilianov mine) is a magnetite deposit, whence small quantities of ore were got for the Kussa ironworks. It is titaniferous, and forms in conjunction with garnet and chlorite a curious mass, upon which are well-grown crystals of the two last-named minerals.

We now come to the second group : here most of the mineral deposits are grouped around Lake Ilmen, near the township of Miass, and they have been worked at no less than 120 different places. It is generally observed that the richest finds are made in the midst of a vein, which points to infilling having proceeded from the exterior towards the centre, crystallization towards the axis of the vein being unchecked. Although some of the minerals are characteristic for a particular rock, few of them are confined to one kind of rock. Among the commonest is zircon, occurring often in large crystals up to 14 ounces or more in weight (the largest yet found weighed about 8 pounds and was valued at £100 or 1,000 roubles). On the eastern shore of Lake Ilmen zircon occurs in the red orthoclase—granite-veins, in association with monazite and magnetite. Topaz is frequently found, as a rule in colourless crystals, but sometimes they have a dirty yellow tinge. Many crystals have been got, weighing 14 ounces or more, and some even nearing 9 pounds in weight : they were estimated at values ranging from £100 to £300. Sodalite occurs in the miassite (claeolite-biotite-syenite) in lovely sapphire-blue crystalline masses, and molybdenite is recorded from two localities. Among other minerals of more or less industrial interest are ilmenite, titanite, magnetite, graphite, corundum, apatite, fluorspar, cryolite, monazite, etc. L. L. B.

EASTERN EXTENSION OF THE WITWATERSRAND MAIN REEF.

La Technique des Mines d'Or du Witwatersrand. By LÉON DEMARET. *Bulletin de l'Association des Ingénieurs sortis de l'École de Liège*, 1897, *new series, vol. xxi., page* 46.

The author submits a theory of his own as to the extension of the main reef series to the east of the Vogelfontein fault, a theory which amounts to asserting that the Rietfontein reef is a prolongation of the main reef, and for the following reasons :—

(1) The bearing of the outcrops at Rietfontein is parallel with those at Modderfontein, indicating a thrust towards the south of the central portion of the Rand by the granitic mass to the north of Johannesburg, with fractures at Witpoortje and Vogelfontein.

(2) Messrs. Hatch and Chalmers mention a fault to the east of Rietfontein, and the existence of sterile rocks with coal-seams on the Driefontein and other farms (Brakpan colliery) which leads to the presumption that the lips or edges of the fault have been washed away into a basin where these recent rocks were deposited.

(3) Between Rietfontein and Nigel, only about the normal width of the basin is found, and a width much too small between Modderfontein and Nigel

(4) There is no reef proved between Rietfontein and the Alexandra estate.

(5) According to Mr. Draper, the Alexandra estate reef is the main reef, while those who discard this theory admit that the Alexandra estate reef is the Rietfontein reef ; but these two opinions coincide if the Rietfontein reef is, as the author believes, the main reef.

(6) The sterile rocks between the Rietfontein reef and the Modderfontein reef correspond with those between the main reef and the Elsburg reef ; and

(7) The Rietfontein reef gives results that may be compared with those of the main reef, while that of Modderfontein has only given deceptive results.

J. W. P.

PELATAN-CLERICI PROCESS OF GOLD-EXTRACTION.

Note sur le Procede Pelatan-Clerici pour le Traitement des Minerais d'Or et d'Argent. By LOUIS PELATAN. *Revue Universelle des Mines, etc.*, 1897, *series* 3, *vol. xl., pages* 175-191, *and one plate.*

The apparatus employed consists of a wooden vat, the bottom of which is lined with copper, which is amalgamated and covered with a thin layer of mercury; inside the vat is an agitator attached to a vertical shaft. This agitator is a spider with wooden arms carrying steel plates, fixed horizontally a short distance above the bottom of the vat. The ore to be treated is first crushed and then charged into the vat, together with a solution of potassium cyanide, common salt, and, in case of need, an oxidizing agent like sodic peroxide. If the ore to be treated is acid, quicklime can also be added. The mixture is kept in motion by the agitator, and an electric current is at the same time passed through the vat, the agitator forming the anode and the mercury at the bottom of the vat is the cathode. Under the simultaneous action of the solvent and the electric current, gold and silver are rapidly dissolved and deposited in the form of an amalgam at the bottom of the vat; any coarse particles of gold slowly settle down and are amalgamated directly by the mercury, the surface of which is always kept bright by the action of the electric current. Ores from somewhat over 200 mines have been submitted to this process; when crushed to a 40 sieve over 50 per cent. of the ores gave an extraction of over 80 per cent., but when passed through an 80 sieve 75 per cent. gave an extraction of over 80 per cent.

The author calculates the cost of the process as follows, including the cost of crushing the ore:—

	Per Ton of Ore.	
	Francs.	s. d.
Chemicals	4·00	3 3
Power (30 horsepower per 100 tons per 24 hours)	0·75	0 7
Labour	1·00	0 10
Maintenance and depreciation	0·25	0 2
Totals	6·00	4 10

He further states that the process is being employed in eight mills in North America, but gives no data as to either working costs or working results obtained. [This process is very similar to the Hannay process proposed some years ago.]

H. L.

GRAPHITE-DEPOSITS OF THE BAVARIAN AND BOHEMIAN HIGHLANDS.

Zur Kenntniss der Graphitlagerstätten: I. Die Graphitlagerstätten des Bayerisch-böhmischen Waldgebirges. By DR. ERNST WEINSCHENK. *Abhandlungen der Mathematisch-physikalischen Classe der Königlich Bayerischen Akademie der Wissenschaften*, 1898, *vol. xxi., pages* 509-564, *with* 2 *plates.*

A perusal of the introduction to this careful and elaborate monograph reveals to some extent the keynote which the author strikes throughout; he is not one of those who believe that graphite is invariably a product of slow regional metamorphism; he does not believe that it is always the last link in the chain of organic carbonaceous substances which begins with peat and passes on through lignite, brown coal, bituminous coal, and anthracite. He claims that chemical

experiment has utterly failed to bear out the hypothesis that graphite is nought else but a coal from which everything but carbon has been gradually eliminated. All graphite-deposits are, he holds, divisible into two great groups, and these again into several subdivisions according to type localities. The following is a summary of his classification :—

I. *Vein-like Occurrences.*—These, generally speaking, are the purer of the two, and therefore of considerably greater industrial importance.

(*a*) *Ceylon Type.*—Veins of scaly or fibrous graphite run through granitic or closely associated rocks. The "country" is often highly decomposed, and then consists mainly of kaolin and similar decomposition products. Used for crucibles.

(*b*) *Borrowdale Type.*—Fine-scaled graphite in veins coursing through "greenstone-porphyry." The gangue-material is chiefly calcspar, brownspar and quartz, wherein are nests and lumps of very fine graphite, especially suitable for the manufacture of pencils.

(*c*) *Batugol Type.*—The graphite from this district in the province of Irkutsk is finely fibrous, purer even than that of Cumberland. The veins run through a granitic or dioritic rock, while in the closely adjoining limestones (altered by contact-metamorphism) are great lumps of pure graphite, suitable for pencils only.

II. *Bed-like Occurrences.*—(*a*) *Passau Type.*—In the easternmost corner of Bavaria, bounded on the south by the Danube, and by the Austrian frontier on the east, are gneisses and gneissose rocks impregnated with scaly graphite, which at times accumulates into lenticular masses of rich mineral. These occur preferably in the immediate neighbourhood of intercalations of granular limestone, altered by contact-metamorphism. Both the graphite-bearing rock and its near neighbours are highly decomposed, so that kaolin, opal, and other decomposition-products are found in intimate association with the graphite-deposits. The genetic connexion of these with the Ceylon type (*a* of Group I.) is so close that, from the point of view of genesis, the distinction between vein-like and bed-like occurrences is narrowed to vanishing-point.

(*b*) *Schwarzbach-Krumau Type*, occurring in the southern Böhmerwald, appears to be the most widespread of any. The lenticular form of the deposits, their geological relationship with limestone-intercalations, their frequent association with kaolin and other decomposition-products, connect them closely with the Passau type, from which they are differentiated by the more compact, less crystalline character of the graphite.

(*c*) *Paltenthal-Kaisersberg Type.*—On the northern border of the central zone of the Styrian Alps is a highly metamorphosed system of Carboniferous shales, clay-slates, limestones, and conglomerates with coal-seams—the coal of which has passed into graphite. The latter indeed preserves completely, in some cases, the appearance of the coal from which it is derived. It is very compact, and, despite its great purity, is often extremely hard. Used for crucibles.

The foregoing classification demonstrates in the author's view the diversity of origin of the various occurrences of graphite. He then passes on to a detailed description of the deposits worked in the frontier highlands of Bavaria and Bohemia.

North-east of Passau, near the Austrian frontier, the gneisses of the Bayerischer Wald are rich in occurrences of graphite. In payable quantities, however, the mineral is restricted to a comparatively small area, and it has been the object of mining operations from the earliest historical period. As one approaches the frontier, a granite-mass takes the place of the gneisses, and simultaneously with this substitution the graphite disappears, reappearing farther north-east in the

gneisses around Schwarzbach in Bohemia. Thence following generally a north-easterly strike, the occurrences are traced in varying number and importance as far as Krumau.

The Passau graphite occurs in large scales, easily separable from the matrix, and in its refined condition furnishes excellent material for crucibles of the best quality. On the other hand, the Bohemian graphite occurs either in very minute scales or in a compact form, and is in part applied to the manufacture of pencils, in part to that of crucibles, but the latter are of an inferior quality to those of Passau.

Naturally, the methods of refining vary in the two districts. In that of Passau, the graphite being scarcely at all brittle, it is easily rid of the pyrites and other brittle impurities. The method is to crush the whole of the graphite-bearing rock, so that the brittle constituents are reduced to a fine dust, while the graphite-scales remain unchanged. The dust is then blown or sifted out, and the mass of material left behind contains about 90 per cent. of graphite, the remaining impurities being chiefly mica-minerals; but all those constituents which would endanger the refractory qualities of the graphite are found to have been removed.

The more compact Bohemian graphite, in so far as it is suitable for pencil-manufacture, is put on the market just as it is; but the less pure, too dense varieties are ground fine, and by settling processes freed from the heavy ore-constituents. The process of concentration cannot, however, be carried much farther than this, and the so-called "refines" are really very little richer in graphite than the crude mineral which contains on an average 50 to 60 per cent.

Coming, then, to a general review of the lithology of the Bavarian and Bohemian areas, the author lays special stress on the highly decomposed condition of the graphitic-gneiss and the associated gneisses, syenites, etc. Rock-decomposition of so far-reaching a character, the same at great depths below the surface as near the surface, is, indeed, uncommon, and points to erosive agencies other than those of the atmosphere. When the soft and decomposed rock is seen to harden in depth, this is found to be an indicator of the thinning-out of the graphite-lens; but, if working be carried on deeper down still, one may yet come upon other masses of graphite, and these are again associated with decomposition-products, such as those which accompany the lenticular deposits comparatively near the surface. In yet other cases no signs of decomposition are noted in connexion with the graphite-lenses; and, once the weathered surface-stratum has been cut through, the rocks are hard, compact, presenting a comparatively fresh appearance. The graphite-bearing rock itself is then very tough, and the winning becomes a rather costly matter. It is curious to note that, while in one and the same complex of deposits, one series may be characterized throughout by soft, decomposed rocks, the series in immediate proximity to it may be equally characterized by hard and unaltered rocks. This variation in character appears, on the whole, to be confined to the syenites and gneisses, the granitic rocks, porphyrites, and gabbros remaining generally fresh and unaltered.

The author next proceeds to describe in great detail the contact-metamorphosed limestones, the syenitic rocks, the massive plagioclase rocks, the granulitic rocks, the gneisses and mica-schists of the Passau district, also the similar limestones, granitic rocks, gneisses, and graphite-schists of the Schwarzbach-Krumau district, from the study of all of which he deduces the following conclusions:—

The formation of the graphite-deposits of the frontier highlands of Bavaria and Bohemia is most probably due to gaseous exhalations of not very high temperature, issuing presumably from the granite-massif which crops out at the frontier itself.

These exhalations (of which carbon monoxide, with carbon monoxide compounds of iron and manganese, with cyanogen compounds of titanium, with carbon dioxide and water, were doubtless the chief constituents) found their way up through the "country rock," using preferably the natural channels [fissures, cracks, clefts, etc.]. They were especially active at those points of weakness which had been determined at the junction of various flexible rocks by the results of regional folding.

In these rocks, such portions were most easily attacked as contained very fissile minerals, or had been greatly shattered by tectonic movements. Then the deposition of the graphite was completed by decomposition of the carbon monoxide; at the same time there was extensive alteration and hydration of the country rock (carbon dioxide and water being the chief decomposing agents), together with the incoming of large quantities of iron and manganese oxides, and the formation of small quantities of rutile.

In any event, the association of organic substances with all these processes is excluded—whether as original constituents of the rocks, or as asphalt or petroleum secondarily brought in through fissures in the strata. L. L. B.

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FORMATION OF GYPSUM AND OTHER MINERALS FROM PYRITES.

Sur les Produits de Décomposition des Pyrites du Bassin de Paris, de Naxos et de Susaki près Corinthe. By A. Lacroix. *Bulletin de la Société française de Minéralogie*, 1898, *vol. xx., pages* 288-308.

In the first place, the author draws attention to the two principal kinds of alteration which marcasite and pyrites undergo:—One, the hepatic alteration, taking place in deposits *in situ* where the pyrites, subjected to slow oxidation, retains its original form, but changes gradually from the periphery to the centre into limonite, hæmatite, etc. In this mode of alteration, if the matrix be calcareous, gypsum is formed, crystals of it coating the interior of hollows in the limonitized nodules. The second mode of alteration is the saline, which takes place wherever pyrites is exposed to rapid oxidation. In this case, the first products are melanterite ($FeSO_4 7H_2O$) and sulphuric acid. The oxidation of the former, and the action of the latter on the matrix rock give rise to a series of secondary products which are especially abundant in the plastic clay of the Paris Basin, but less so in the oligocene blue marls.

First and foremost among these secondary products is gypsum (so largely worked round Paris), the sulphuric acid from the decomposed pyrites acting alike on the Meudon chalk, on the green and blue marls of Romainville, and on the plastic clay. Websterite, globular sparry iron-ore, halotrichite, apatalite, and a mineral allied to copiapite, are among the other secondary products. The author describes the various crystalline forms of the gypsum, and the habit and local characteristics of the other minerals. He then points to a similar occurrence in the cliffs of the island of Naxos, where Tertiary grits are overlain by clays rich in cubes of pyrites, and these, in turn, are covered by calcareous conglomerates, overlain by granitic conglomerates. Moreover, in the Susaki ravine, near the eastern entrance of the Corinth Canal, is a *solfatara*, whence issued steam, carbon dioxide, and hydrogen sulphide. The latter decomposes into sulphur and sulphurous acid, which itself takes up oxygen to form sulphuric acid. The last-named, attacking the neighbouring rocks, forms gypsum from calcareous conglomerates (Pliocene), and from the serpentine, in the first instance, soluble iron, magnesium, and other

sulphates. These disappear in time, leaving as a residue opal, with the microscopic structure of the serpentine still intact. The opal is generally impregnated with gypsum, brought in by surface-waters from the overlying gypsiferous conglomerates; in one locality the opal is impregnated with marcasite. This marcasite decomposes, by the action of the acid-charged steam from the *solfatara*, into melanterite, and the latter, as before mentioned, into gypsum. On the south-eastern coast of the Melos, similar occurrences are observed. L. L. B.

ARRANGEMENTS FOR ROPE HAULAGE.

Description des Transports Mécaniques par Cable, pour Mines: Système Dinnendahl et Système Förster. By Léon Navez. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1896-7, *series* 3, *vol.* v., *pages* 415-421, *with* 2 *figures in text and* 2 *plates*.

These two systems of endless-rope haulage, which are sometimes combined in the same plant, are largely applied in Germany both underground and on the surface, giving good results. As in all mechanical haulage-plants, they require a well-laid and well-kept track, with the rails perfectly parallel with the line of the rope, while the tub axles must be well lubricated. A haulage rope may work 18 or 24 months before being renewed; but a fresh splice must be made from time to time, while in damp mines the rope must be greased. The average speed is 2 feet per second; and about 16 horsepower is required for each mile of track (10 horsepower per kilometre).

The wire rope, $\frac{1}{2}$ to $\frac{3}{4}$ inch (12 to 20 millimetres) in diameter, guided along the centre line and above the track, draws along the tubs, spaced evenly apart, in its rectilineal motion, as in chain haulage. When there are knots in the rope they must be wound with hemp for preventing wear against the forks; and with smooth ropes several forms of clips, or forks, are used according to circumstances.

A common form of clip is in the nature of a pair of tongs, of which one arm half encircles the rope, while the other, grooved to fit, is pressed against it by the pull; but this arrangement has the disadvantage that, when the running rope is long, its longitudinal motion is complicated by a tortional one, which draws along with it the clip, and therefore the tub, causing it to leave the rails. This difficulty is obviated by the Heckel coupling, in which a grooved ring is fastened to the rope by a gib and cotter, while a second ring, turning freely in a groove formed in the outside edge of the first, has an eye for receiving the chain of the tub.

The turning fork, in the shape of a crank, is more used, especially on the level or for slight gradients. It is inserted in a socket riveted to the front end of the tub and about 1 foot above its top—not in its centre line but along a line corresponding with the crank's eccentricity; and the consequence is that the pull of the running rope is sufficient to clamp itself in the fork, that turns in its socket.

In the Dinnendahl system, the rope is supported at intervals, and also guided, by special pulleys, the upper portion of which, trunconic and with slightly concave rim, turns continually as the rope passes, and keeps it constantly in the centre line of the track, while the lower portion of larger diameter than the upper and forming a kind of star-shaped flange, while being capable of revolving independently of it, permits the passage of the forks in the notches between two teeth. In straight portions of the road, these star-like pulleys are inclined alternately to the right and left; but on curves they are hung horizontally, while the stars of the inside pulleys may be suppressed. All the guide pulleys are

mounted on horizontal beams turning on hinges, so that they may be pushed out of the way, so as to leave the whole sectional area of the road clear when required.

The tension-pulley is mounted on a truck with a vertical counterweight, which moves in guides so as to yield readily in the event of any unusual strain, as for instance when a tub gets off the rails ; and these movements of the counterweight constitute signals that something has gone wrong.

The groove of the driving-pulley is lined with pieces of leather, stamped out by machine to a suitable form, set on edge and made fast by a wire cord passing through holes in the leather along a circle midway between the leather groove and the cast-iron groove.

In the Foërster system, which differs but little from that of Dinnendahl, the rope is more tightly stretched, so that supporting pulleys are not required—at any rate on straight roads. Curves are passed round according to their tangents, the change of direction taking place sharply, the rope being guided by a horizontal grooved pulley of large diameter, and the turning of the tub being facilitated by the use of special plates cast with guide rails. J. W. P.

UNDERGROUND MACHINERY AT THE ST. CATHERINE SHAFT, BASCOUP COLLIERY, BELGIUM.

Notice sur les Installations mécaniques du Fond du Puits Ste. Catherine du Charbonnage de Bascoup. By EDM. BRIART. *Revue Universelle des Mines, etc.*, 1897. *series* 3, *vol. xxxviii., pag.* 172-184, *with* 3 *illustrations in text and* 2 *plates.*

The underground plant consists of a hauling-engine and a direct-acting pump, both notable for their compactness rather than for any other specialty. The cages are double-decked, each deck taking two tubs end to end. The system of haulage is by an endless over-tub chain ; the length of the main haulage road is 9,840 feet (3,000 metres) ; and it is driven perfectly straight with a uniform gradient of about 1 per cent. towards the shaft. Branch roads for hand-putting are set off from the main road about 984 feet (300 metres) apart to open up the various seams. Near the shaft, the main road is divided into two branches, one for the full tubs, the other for the empties, having a gradient of 2 to 2½ per cent., the former towards the pit-bottom, and the latter from it. The hauling-engine, placed at the point where the two roads branch off from the main road, is a 20 horsepower single cylinder engine, placed above the roadway, and driving a Briart clip-pulley, which sets the chain in motion. This pulley lies across the haulage-road ; and there are a pair of guide-pulleys beneath it at different levels for the chain. The clip-pulley consists of a cast-iron boss, to which two discs of sheet-iron are riveted, carrying between them a forged iron rim. Into this rim are screwed iron clips of a suitable shape to gear into the links of the chain. These clips have long threaded shanks, which are screwed home with a new chain, and as the latter wears they are screwed out by half a turn or so, thus increasing the effective diameter of the pulley as may be required. It is necessary that all the links of the chain should be accurately gauged to the same size.

The pump is a straight-line, direct-acting, double-ram pump of ordinary type ; and was specially designed so as to occupy as small space as possible.

H. L. AND J. W. P.

BALANCE CAGE.

Charbonnage du Grand Hornu : Établissement d'un nouvel Accrochage au Puits No. 7 : nouveau Système de Frein pour Balance : Taquets hydrauliques. By J. DE JAER. *Annales des Mines de Belgique*, 1898, *vol. iii.*, *page* 139-142, *with illustrations in text.*

Coal is wound, in No. 7 pit, which is 2,400 feet (729 metres) deep, from the levels of 1,850 feet (564 metres) and 2,076 feet (633 metres) and also by No. 12 shaft from the level of 2,323 feet (708 metres) to that of 2,076 feet (633 metres) whence it is conveyed to the surface by the cages of No. 7 pit. With the object of restricting No. 7 pit to the winding of coal and No. 12 pit to letting down materials, the cross-cut driven towards the north from the bottom of No. 12 pit has been continued, so as to communicate with No. 7 pit at the depth of 2,323 feet (708 metres), which has permitted the formation at this level of a new landing for No. 7 pit.

The double landing, 66 feet (20 metres) long, is supported by flange rails $4\frac{3}{4}$ inches (12 centimetres) high and $2\frac{3}{4}$ inches (7 centimetres) wide in the flange, bent to a semi-circular arch $8\frac{1}{2}$ feet (2·5 metres) wide and 14 feet (4·25 metres) high from the floor to the crown. These bars are spaced $3\frac{1}{4}$ feet (1 metre) from centre to centre ; and the intervals are closed by arches half a brick thick and of only 3 inches (8 centimetres) rise, the spaces between them and the rock being filled in by rough masonry. The two floors, each $7\frac{1}{2}$ feet (2·25 metres) high, are connected by a balance lift, 36 feet (11 metres) from the centre line of the shaft, the upper floor being carried by rolled joists which form ties to the arched frames.

The balance lift is provided with a special form of brake. On one of the pulley shafts is keyed a disc, the crank-pin of which actuates the rod of a piston working in a cylinder full of oil that oscillates on trunnions, the two ends of the cylinder communicating by a narrow passage, in which the oil is made to pass backwards and forwards while the piston works ; and this passing of the oil to and fro in the narrow passage creates a resistance that may be varied by more or less opening a cock in the middle of the passage. When the cock is opened one-fourth, a tub-load of rock is let down in 7 seconds, a speed which cannot be exceeded without altering the position of the cock. Trials have shown that the resistance of this brake, varies with the position of the piston, from a maximum when the crank is on the centre to a minimum when it is at an angle of 90 degrees. J. W. P.

SAFETY-HOOK FOR PREVENTING TUBS FROM RUNNING OR SLIDING DOWN INCLINES.

Accidents sur les Plans Inclinés : Grappin de sûreté. BELGIAN MINISTERIAL CIRCULAR. *Annales des Mines de Belgique*, 1898, *vol. iii.*, *page* 158.

Inasmuch as accidents on inclines due to replacing upon the rails a tub that has left them are comparatively numerous, it is advisable to draw the attention of engineers and mine-owners to a very simple arrangement calculated to diminish this danger, as pointed out by the mine inspector of the first division. The haulage-rope is attached, as usual, to a ring connected with the two chains of the tub, and also with a third chain of about the same length, terminating in a flat hook at least 2 inches (5 centimetres) wide. In normal working, this third chain is twisted round the two draw-chains so as not to drag upon the floor ; but, in the event of a tub leaving the rails, the grapple is to be hitched on to one of the sleepers of the track, thus preventing the tub from running or slipping down while it is being replaced upon the rails. J. W. P.

ROLLER BEARINGS FOR MINE TUBS.

Talks about Pit-car Trucks. By - Barker. *Journal of the Illinois Mining Institute*, 1894, *vol. iii., pages* 62-66, *with figures in text.*

The wheel resembles an ordinary self-oiling wheel in outward appearance, with the exception that the hub is a trifle larger. The hub is cast around a chill, which produces a hardened surface on its interior, and is of sufficient size to accommodate a ring of rollers, 14 in number, which surround the journal. The rollers extend the entire length of the journal, with the exception of about 1½ inches on the outer end, which is matched by a corresponding circumferential groove, partly in the outside surface of the hub and partly in the inner face of the cap, so that when the cap is bolted to the hub a circumferential groove is formed to match the groove in the journal. In this groove are seven bulbous-ended short rollers, the bulbous part occupying the groove, while the short rollers attached to one end, which are of the same diameter as the rollers in the hub, occupy the space at the end of the journal, between it and a flanged rim inside the cap. The bulbous portion of the short rollers, fitting as they do partly into the groove in the journal, and partly into the groove formed by the hub and the cap, prevents an end-thrust or lateral motion of the journal, and consequently obviates the necessity for a linch-pin; it also prevents the back of the hub from grinding against the collar, both of which are causes of friction. The rollers, being 14 in number and $\frac{9}{16}$ inch in diameter, whilst the bulbs are 7 in number and 1 inch in diameter, there is consequently an intermeshing of the lines of the bearing of the rollers with the bulbous rollers, and the lines of bearing on the journal are so closely grouped as to prevent wedging.

Although the use of a lubricant is unnecessary, it is recommended that a small quantity of black oil should be introduced two or three times a year, so as to prevent the accumulation of rust in the bearings.

In one experiment, a wheel weighing 60 lbs. was placed on an axle and revolved for eight days at a speed of 200 revolutions per minute, equivalent to a running distance of something over 800 miles. During the eight days, the wheel showed no signs of heating, although no lubricant whatever was used. A car loaded with iron, which, with its own weight, amounted to over 4,000 lbs. was easily started and drawn along a level track by one finger of a man's hand. Again, a car, weighing 1,500 lbs., with 8 men upon it, was pulled with a piece of ordinary wrapping twine.

The use of this bearing allows a greater number of cars to be hauled underground with the same engine or horse-power. M. W. B.

MINE HORSES.

Considérations pratiques sur l'Emploi du Cheval de Mine dans le Bassin houiller du Gard. By Ernest Boissier. *Bulletin de la Société de l'Industrie Minérale*, 1896, *series* 3, *vol. x., pages* 295-382 *and* 485-564, *with diagrams.*

Although mechanical motors are gradually replacing horses for hauling loads, locomotives and compressed-air motors can only work under rigorously fixed conditions, not applicable to all branches of work, so that the more costly and less economical horse is still indispensable in many circumstances. Horses constitute a sufficiently heavy item in the expenses of mining companies to show the advisability of turning them to the best possible advantage as motors, and at the same

time avoiding overwork, which may occasion various maladies and wear out the animals prematurely. On the judicious selection and management of horses depends, to a large extent, a proper execution of the work, and also the preservation of the capital, often considerable, represented by horse-flesh. The object to be attained in the utilization of mine horses is to increase their useful effect as far as possible (1) by a judicious selection and suitable adaptation to the special work required; (2) by a rational and economical feed permitting the animal to repair the losses occasioned by work and also to maintain a certain reserve of power for prolonging their life and efficiency; and (3) by the improvement and keeping in order of stables, harness, rolling stock, and permanent way.

The above considerations are treated under the various heads of the horse's work, both underground and on the surface, with the general conditions and also those which cause the work to vary, including the haulage of waggons and sets of tubs, the fitness of horses for their work, and also overwork; the choice of horses, including acclimatization and training; feed, as to quantity, quality, and preparation; stables, including those underground, and their ventilation; litter, grooming, etc.; shoeing, harness, and ailments.

The average cost of a day's work by the mine horse is arrived at; and a description is given of the dynamometrical trials carried out by the author, who comes to the conclusion that the effort exerted by a horse for starting a set of five tubs, weighing together 6 tons, on a horizontal line of way, is about 0·78 ton, or 143 pounds (65 kilogrammes) per ton, amounting to 6·5 per cent. of the load.

The most interesting investigation for determining the work of mine horses is, that relating to the coefficient of haulage, because it is that which serves as basis for calculating the work, and its determination by direct experiment is of capital importance in all haulage contracts. Such trials present numerous difficulties; and one often encounters, for the same load, considerable variations depending on the state and direction of the track, lubrication, and the manner of leading the horse. All these conditions exert a marked influence on the results obtained, which are in some cases more than double what they are in others; and it is only by varying the conditions and repeating the experiments many times that a general mean, applicable to most cases, can be obtained.

For lines of 31 inches (80 centimetres) gauge with wheels of 15 inches (38 centimetres) diameter, and under the best possible conditions, *i.e.*, on a straight and level track, with clear and clean rails, and tubs well lubricated, in normal working and excluding the effort of starting, a set of 5 tubs, weighing together 6 tons, showed a mean resistance of 434 foot-pounds (60 kilogrammetres), 22 pounds (10 kilogrammes) per ton, or 1 per cent. of the load, reduced in some exceptional cases to 18 pounds (8 kilogrammes) per ton.

For underground haulage, however, taking into account the startings and curves, with average state of way and tubs, a resistance of 108 foot-pounds (15 kilogrammetres) per ton must be allowed for on the level; and it is this figure of 1·5 per cent. which should serve as a basis for calculating the work done by horses, while it is also that which the author has generally arrived at as a mean by numerous trials under the most various conditions, either on pieces of level line, or by taking the mean of the forward and return journeys over long distances and with various gradients.

On endeavouring to ascertain the total amount of work performed by horses underground, during the day, the author has arrived at a mean of 12,095,255 foot-pounds (1,672,200 kilogrammetres), which, however, he regards as the minimum, because his results were obtained with regular loads, which are often increased in

practice, while the drivers, finding themselves watched, might have led their horses with greater care than usual. In any case, he does not consider that the daily work of a mine horse exceeds 14,466,280 foot-pounds (2,000,000 kilogrammetres).

J. W. P.

UNDERGROUND HORSE-HAULAGE.

Recueil : Efforts de Traction. By M. Damon. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1896, *pages* 92-94, *with* 3 *plates*.

Owing to the whole output of the Commentry colliery—about 3,500 tubs daily—being concentrated at a single shaft, haulage on the surface was suppressed; but, on the other hand, the underground haulage was greatly increased. A cross-cut about ¾ mile long, placing the inclines serving the various sections of the colliery into connexion with the central shaft, is laid with a double track of 21 inches (54 centimetres) gauge and a gradient of 1 in 166 (6 millimetres per metre), traversed by the sets of full and empty tubs, of which sixteen, each containing 17½ cubic feet (5 hectolitres) of coal go to a set. Owing to the large number of turn-out points and other causes, horse-haulage was adopted; and, as it was important to get the greatest amount of work out of the horses, while keeping them in good condition, and as the speed is nearly constant, the number of tubs forming the set was determined by a dynamometer-truck, formed out of an ordinary tub with plate-iron body, mounted on four loose wheels and having spiral-spring draw-links at the front and back.

The fore-end of the tub-floor carries a bracket, in which works the pivot of a bent lever with the two arms forming a right angle. The arms are connected, the shorter and vertical one with the draw-link, and the longer horizontal arm, by a rod, with a beam, pivoted in the tub-body, and having a sliding weight at one end. To the other end is attached a float moving in a cylinder full of water, in such a manner that a pull at the draw-link tends to plunge the float deeper into the cylinder, and thus create a gradually-increasing resistance; and equilibrium is established when the thrust of the water, multiplied by the ratio of the lever arms, equals the tractive effort. The float-end of the beam is provided with a metallic pencil, which is kept pressed by a small spiral spring against a cylinder carrying a continuous band of metallic paper, taking its motion from an eccentric on one of the tub wheels. Placed after the first tub of a set, this dynamometer-truck records the variations of effort exerted by the horse, the state of the track, and the degree of lubrication of the tubs.

The diagrams obtained show clearly the increased effort at starting and on passing various special points in the track, such as points and crossings, while they differ between one horse and another; and the effect caused by a tub getting off the rails is very manifest. In part of the road where heavier rails have been laid, the diagram shows an increased haulage effort due to the presence on the rail-face of mud or dust, the influence of which increases with the surface of contact, so that it is advisable to use rails with a narrow table. The diagrams also show that the above-named gradient, which was formerly considered to be that of equal resistance, is now too sharp owing to better lubrication and maintenance of wheels and tracks; and the more regular portions of the diagrams indicate 1 in 250 (4 millimetres per metre) as the gradient of equal resistance. The means of observations extending over several months show that the work performed by a horse varies from 83 to 93 ton-miles (135 to 150 ton-kilometres) and from 61·6 to 68·5 useful metrical tons.

J. W. P.

IRON-ORES OF ELBA.

Del Fosforo e dell'Arsenico nei Minerali di Ferro dell'Isola d'Elba. *By* P. Toso. *Bollettino del Reale Comitato Geologico d'Italia*, 1897, *series* 3, *vol. viii.*, *pages* 216-248, *with* 7 *figures in text.*

The Elban iron-ores are much valued because of their richness in metallic iron, and the relatively small proportions of phosphorus and arsenic which they contain: that of Terranera, for example, yields on analysis more than 68 per cent. of iron, with 0·005 per cent. of phosphorus and mere traces of arsenic. The ores of Calendozio, however, contain rather more phosphorus, and, in 1889, when they were being more actively worked, they were mixed up with the other, purer ores of Rio Albano, and this gave rise to complaints on the part of the blast-furnace owners who purchased the ore. As a consequence of these complaints, a chemical laboratory was established in 1890 at Rio Marina, and since then many analyses have been made. In 1895, arsenic and phosphorus were found in the ores of Il Puppaio (Rio Albano) in quite unprecedented proportions: 0·015 and 0·510 per cent. of arsenic; and 0·083, 0·062, and 0·190 per cent. of phosphorus. Working was accordingly stopped in that particular district of the mine, and the older district of Grattarino, which is far less costly to work, was opened up again.

The following are representative analyses:—

	Iron. Per Cent.	Phosphorus. Per Cent.	Arsenic. Per Cent.
Rio ore, washed	60·00	0·016	—
,, ,, unwashed	54·55	0·024	—
Vigneria ore	61·05	0·012	—
Terranera ore	68·15	0·005	—
Calamita ore	58·61	0·015	—
Pulette (ore in a fine state of division, washed up on the beach by the sea-waves).	59·63	—	—

The author then proceeds to deal with (1) the origin of the metalliferous deposits; (2) the nature of the rocks with which the ores are associated; and (3) the characters, conditions of deposition, etc., of the ores.

1.—There is a general agreement that ferruginous thermal springs were the originating cause. It is uncertain whether the mineral reached the surface in the form of sulphides dissolved in alkaline waters altered later on into sulphates, and then into oxides, thanks to the presence of air and calcareous substances; or whether it came up as an iron carbonate in acid solution. The first supposition would explain the abundance of the pyrites-crystals which lie packed between the clays of the ore-bed in the Rio and Vigneria mines, or amid the mass of compact ore of Terranera. Both clays and compact ore will have sheltered the pyrites from atmospheric agencies, and will thus have arrested its oxidation.

2.—The country rocks are, in ascending order:—

(*a*) Pre-Silurian gneissose and mica-schists (as at Calamita); slaty schists (Terranera); saccharoidal dolomitic limestones and calc-schists (Calamita).

(*b*) Permian quartzites, sandstones and mica-schists (Rio Marina and Rio Albano).

(*c*) Infra-Liassic cavernous limestone (same localities).

(*d*) Upper Liassic variegated shales (Rio Albano).

The whole series does not occur in any one mine. At one place, one may find only Pre-Silurian and Permian schists; at another, only Permian quartzites, with the Infra-Liassic limestone, and the Upper Liassic shales, and so on.

3.—In the Vigneria mine, spathose iron ore and hæmatite predominate. Lenticles of altered schist (*bianchetto*) are frequently interbedded with the ore. At Rio Marina, the far-spreading, irregularly bedded ore-deposit rests on the ancient mica-schists and Permian quartzites or sandstones, and it is cut off at many points by the cavernous Infra-Liassic limestone. No lenticles of *bianchetto* are seen here, and the ore occurs in the form of compact hæmatite with very small quantities of clay. The author discusses in some detail the mode of formation of the Rio Marina deposit, and arrives at the following conclusions with regard to it :

(*a*) The ore attains an exceptional thickness in the Fabbriche and Pozzo Fondi districts of the mine, because not only did the mineral fill up the hollow produced by faulting and fissuring, but also in part replaced calcareous rock.

(*b*) The ore is found in beds of compact mineral, with less clay than elsewhere, precisely because the Infra-Liassic limestone is less frequently interrupted by argillaceous lenticles.

(*c*) To the west, the deposit is bounded by limestone, always at the same distance from the fissures, which are the presumed line of outburst of the thermal springs.

Phosphorus and arsenic are impurities practically unknown in the Fabbriche and Pozzo Fondi divisions ; but when one examines the peripheral deposits, the farther away these are from the centre of origin, the richer they are in phosphorus and arsenic, as, for example, Antenna, Cavaccie, and Rosseto. This is explicable on the hypothesis that the phosphates and arseniates, altered into lime salts in the presence of the limestone, were leached out of the ore by acid solutions, but as these became weaker in acid in the distant portions of the deposits their leaching effect dwindled away. Moreover, the leached-out phosphates, at anyrate, would naturally be deposited in greater quantities at the periphery than elsewhere.

The Rio Albano mine again exhibits characteristics unlike those noticed at Vigneria and Rio Marina. Beds of siliceous mineral are intercalated in the metalliferous deposits, more especially in the uppermost portion. In the Puppaio district of the mine there are, as already mentioned, considerable variations in the proportions of phosphorus and arsenic. In the Calendozio district, on the western fringe of the Rio Albano area, the ore of the lower bed, which is a replacement of limestone, is highly phosphatic—for the same reasons as those which have been adduced in the case of the peripheral deposits of Rio Marina. At Calendozio, the mineral at the upper surface is banded in thin, nearly horizontal, layers ; in these are many cylindrical tube-like hollows, around which the ore is arranged in concentric vertical sheaths. These appear to point to the former presence of decaying plant-stems, around which the mineral was deposited. It is known that phosphates in solution concentrate by preference around organic substances. Arsenic is most abundant in the brown hæmatite of Il Puppaio and in the Tarambano district. It may be inferred that the arsenic was derived from the thermal springs, as it diminishes in the inverse ratio of the distance of the ore from the fissure-line. It, too, has been much leached out by acids, but at Il Puppaio the clays have acted as an effectual bar to the further dispersion of the arsenical salts.

At Terranera, the largest mass of mineral that yet remains to be worked is made up of a compact spathose ore, which rests directly upon gneissose schists, and is overlain by clay slates and *bianchetto*. The deposit is thickest along a north-and-south line ; it thins out eastward, and is cut off altogether to

the west. Here pyrites-crystals occur, not as at Vigneria, in the clays, but within the mass of spathose ore itself. The author suggests that at one time the upper portion of the deposit was connected with that of the Capobianco mine to the west, where manganese is present in considerable quantity.

In the Calamita mine, a dolomitic limestone overlies the gneissose mica-schists, and is, in part, replaced by iron-ore. Beds of calciferous iron silicates enclose huge lenticles of hæmatite and magnetite.

Two appendices, by Messrs. E. Mattirolo and G. Aichino, accompany the paper. The first one contains a careful mineralogical description and a series of chemical analyses of 13 samples of ore from the Rio Marina and Rio Albano mines. The second appendix deals with the determination of the amount of phosphoric anhydride in three rock-samples from the same area. These appendices are the record of work done at the chemico-petrographical laboratory of the Italian Geological Survey. L. L. B.

MANGANESE IRON-ORE OF GIESSEN.

Das Manganeisenerzvorkommen der "Lindener Mark" bei Giessen in Oberhessen. By Dr. Fr. Beyschlag. *Zeitschrift für praktische Geologie*, 1898, *pages* 94-95, *with* 1 *figure in text*.

A bare ½ hour's journey from the town of Giessen, in Upper Hesse, are the openwork mines of the Lindener Mark, started in 1842, and ranking now as the largest of their kind in Germany.

The manganiferous iron-ore is an irregular deposit, resting upon Middle Devonian *Stringocephalus*-limestone, and overlain by 15 to 20 feet of pinkish to white clays. These are followed in their turn by river-gravels. Very little of the limestone has remained unaltered, mostly it has passed into a ferruginous and maganiferous dolomite, and the point where workable ore ceases and dolomite begins is not always sharply marked off. Just as the ore appears to accumulate in pockets and depressions in the upper surface of the dolomite, so the clay dips down into pockets in the upper surface of the ore-deposit. At one point, the ore lies 100 feet thick, but its average thickness does not exceed 25 feet; its quality is very variable. Lenticular and sphæroidal masses of clay form "horses" in the ore; they probably represent hollows caused by running water and filled by detritus.

Regarding the origin of the deposit, it is noticeable firstly that no ore has so far been discovered in juxtaposition with unaltered limestone. Dolomitization was brought about by the leaching-out of the *Stringocephalus*-limestone (which, as it is, contains magnesia) by waters which carried with them the ores in solution. The limestone, diminished in volume, partly took up in lieu of calcite the particles of manganiferous ore, and partly crumbled down—which accounts for the irregularity of its surface. The clays appear to be in part of contemporaneous deposition, in part of later date—probably the residue of erosion of neighbouring shales. All this is supposed to have taken place in Tertiary times.

There are small white flinty nodules in the ore, and as secondary minerals formed within the deposit itself by concentration may be mentioned pyrolusite, polianite, wad and manganite.

It may be worth while to recall here the similar association of Devonian dolomite with iron-ore in the Urals. L. L. B.

GELLIVARA AND GRÄNGESBERG IRON-ORE DEPOSITS.

Die Eisenerzvorkommen bei Gellivara und bei Grängesberg in Schweden und deren Gewinnung. By Prof. Wedding. *Zeitschrift für das Berg- Hütten- und Salinen-wesen im preussischen Staate*, 1898, *vol. xlvi., pages* 69-78, *and* 1 *plate*.

The author points out that these deposits differ from most of those hitherto worked in Sweden, therein, that the ores contain a large amount of phosphorus, an impurity from which Swedish iron-ores are, as a rule, so remarkably free.

1. *Gellivara.* This locality lies in Norrbottensläin, Lapland, some 50 miles north of the Arctic circle and 140 miles north of the harbour of Luleå, with which it is connected by a state railway. The highest summit of this mountain of ore is 2,000 feet above sea-level, and the entire ridge averages 650 feet above the valley-floor. The iron-ore occurs in lenticles in a hornblendic gneiss, only those deposits which come to day above the valley-floor being worked at present; some crop out on the very crest of the ridge. They are all more or less buried under thick morainic deposits, which must always, of course, be removed ere the opencast workings are begun. At one time, these glacial *débris*, together with the barren rock-material, were tipped wherever convenient; but nowadays all is carefully stacked for future use as packing in the underground workings now in course of preparation.

The ore-lenticles in a general way follow the strike of the gneisses, but they do not always lie in the same horizontal stratum, and sometimes one occurs on the top of another. The country-rock is recognizable by means of its felspar, the iron-ore by the apatite associated with it. Sometimes the ore passes into the country-rock through an intermediate band of magnetiferous rock known as *skarm*, too poor in iron to repay working for that, but valuable for the quantity of apatite which it contains. The ores are classed in five categories, according to the percentage of phosphorus, which varies from less than 0·05 to more than 1·5.

The author describes briefly the Johan, Välkomman, Linné and Baron mines, which yield highly phosphoric ores, also the Hermelin, Skåne and other mines, to the number of 14 in all.

For transmission of power, etc., electricity is largely used; it drives the hauling and pumping-engines in the three shafts now being put down, and is used for lighting—the latter an item of no small importance, when one recollects the length of the winter night in these high latitudes. Blasting is done with dynamite, ignited as a rule by gunpowder-fuses.

It is observed that the less apatite the ores contain the tougher they are, and the bigger are the lumps into which they break, while the highly apatitic ores are shattered almost into grains and crystalline fragments. The apatite is usually so arranged in streaks or bands that a little way off it gives to the ore the appearance of a crystalline hornblende-schist, in such wise that the ores may be classified on the spot by a practised eye. As a matter of fact, the overman sorts them into the five above-mentioned categories, causing them to be filled into as many different tubs at the working-face; and it is found that this rough-and-ready sorting is, on the whole, so accurate that it is almost invariably confirmed by the analyst, and very rarely is re-sorting necessary.

The shipping arrangements at Luleå seem to be still rather defective, as the ore cannot be loaded direct from the railway-truck into the vessel's hold. Shipping takes place only in the summer; and during the winter the ore is stacked in heaps according to quality, in readiness for the season when navigation is open. It is proposed by a new company to work up as phosphates for agricultural purposes.

such ores as are rich in apatite, but too poor in iron, and the factory was in course of building in August, 1897.

It is unpleasant to note that the British companies who tried their hand at the working of the Gellivara ores found themselves unable to overcome the difficulties connected with climate, etc. A Swedish company, with its head office in Stockholm, now works the mines.

Turning to the question connected with labour, no use can be made of the nomad Lapps, and workpeople are brought from various districts in Southern Sweden. They numbered at one time 1,750, but a strike took place in the spring of 1897, which has reduced their numbers to 1,500. Many miners left the district, and, once gone, it is no easy matter to tempt men back so far north, where, too, they appear to be poorly housed and ill-fed. The forest-land around Gellivara is crown property, and there is hardly enough suitable building ground available for workmen's dwellings. Most of the miners, their trespass being winked at by the local authorities, have improvised on the crown land their flimsy habitations amid boulders and tree-stumps, but their huts are kept scrupulously clean. There is no co-operative supply-store, and provisions are obtained with difficulty, as few articles of food can be raised in the district, and cattle cannot be kept through the winter. Finally, it may be mentioned that in summer the mosquitos prove a serious hindrance to the miners, who are obliged to wear protective headgear and gloves.

2. *Grängesberg* lies in the district of Kopparberg, near the boundary of the provinces of Dalecarlia and Westmanland. The occurrence here is entirely different from that of Gellivara: it comprises a series of lenticles, belonging to the great metalliferous belt of Central Sweden (wherein few of the deposits are confined merely to the ores of iron); but the phosphatic character of the Grängesberg ore distinguishes it from all the other deposits of that belt. Since 1893, there has been an enormous development of mining here, due in no small measure to the several companies having brought the whole of the mines under one management. Two railways provide the means of transport, and the harbour of Öxelösund is 140 miles distant.

The percentage of phosphorus varies from less than 0·06 to as much as 5 or 7; and here it may be well to reproduce the analyses which the author gives of the Gellivara and Grängesberg ores, for purposes of comparison:—

	Iron. Percentage.	Phosphorus. Percentage.
GELLIVARA.		
Variety A	67 to 70 ...	0·01 to 0·05
Variety B	66 to 69 ...	0·05 to 0·10
Variety C	65 to 67 ...	0·10 to 0·80
Variety D	63 ...	0·70 to 1·50
Variety E	57 to 61 ...	1·5 to 3·00
GRÄNGESBERG.		
Northernmost band ...	62·85 ...	0·890
,, ,, ...	62·18 ...	1·540
,, ,, ...	63·63 ...	1·060
Southernmost band ...	60·42 ...	0·076

Whence it is seen that, on the whole, the Gellivara ores are richer in phosphorus, but those of Grängesberg are tougher and crumble less easily: the former are said to contain small quantities of titanite. The Domnarfvet iron works take those Grängesberg ores which are richest both in iron and phosphorus, the remainder being exported.

Although most of the workings are opencast, in the Bergsbo mine, four shafts have been put down to a depth of 100 feet, and the ore is worked by cross-cuts. They are now carrying the shafts to a level 60 feet below the present floor, and the Mornäs mine goes down to 1,170 feet. The tubs used in these mines have an average capacity of 14 cwts. and their contents are generally tipped direct into 19 tons railway-trucks. The ores are hand-picked, screened, and magnetically sorted by the Wenström system, while the most finely divided material is washed by a stream of water. Iron glance occurs in considerable quantity, and as it must be separated by hand from the non-magnetic material, this constitutes a serious drawback in the sorting process. About one-third of the stuff brought down at the face is barren-rock. Sometimes both ore and country-rock are traversed by veins of pegmatite. As elsewhere in Sweden, the ore-lenticles have the same strike as the country-rock (south-south-west to north-north-east): they run in three parallel bands, the lowest of which is the most important industrially and the richest in phosphorus.

As at Gellivara, electricity is largely used for transmission of power and for lighting purposes—indeed the electric installation is almost ideally perfect. A waterfall from Lake Hellsjön is utilized for 5 turbines (total 550 horsepower), whence power is transmitted over 8 miles of wire to 19 dynamos, with a loss of about 30 per cent.

The workpeople number about 500, with an average daily wage of 2s. 11d. They are well housed, in dwellings built by the company, and they are insured against sickness and accident by a fund to which the employers contribute one-half. The climate is less rigorous, of course, than that of Gellivara, and heavy snow-storms are of rare occurrence. While Luleå harbour is open only for 4 months of the year, the harbour of Öxelösund is open all the year round except during 3 or 4 weeks.

In conclusion, the author points out that about 70 per cent. of the total exports of Swedish iron-ore goes to Germany: the Swedish ores, indeed, are found to form a very useful adjunct to the Upper Silesian ores, and they will prove indispensable to the new blast-furnaces at Kratzwick near Stettin, which have been built for the express purpose of finally ousting British pig-iron from the German market. L. L. B.

IRON-ORE DEPOSITS OF KRIVOI ROG, SOUTHERN RUSSIA.

Übersicht der geologischen Verhältnisse von Krivoi Rog in Südrussland, unter besonderer Berücksichtigung der Eisenerzlager. By A. Macco. *Zeitschrift für praktische Geologie*, 1898, pages 139-149, *with map and plate in text.*

Krivoi Rog, in the Government of Kherson, and close to the border of that of Yekaterinoslav, is a station on the railway from Dolinskaya to the city of Yekaterinoslav, and a branch railway running to Elenovka, brings into communication all the largest mines in the district. Although the iron-ores are said to have been known to, and worked by, the ancient Greeks, mining operations on an extensive scale date only from 1883—that is, the last 15 years or so.

Beneath the Tertiaries, which cover the boundless steppes of Southern Russia, is an Archæan rock-basis of gneiss, granite, and syenite. Between the Archæan and the Tertiary strata is thrust a system of younger crystalline rocks, consisting chiefly of clay-slates and quartzites, and it is in association with the last-named series of rocks that the iron-ores of Krivoi Rog occur. The younger crystalline rocks form a narrow belt stretching north-north-east and south-south-west some 30

miles from the village of Ingulskaya to Sergievka, and reaching its greatest breadth, about 4 miles, at Krivoi Rog. Their folding-in among the Archæan rocks has saved these rocks from the destructive agencies which in far-gone ages swept off the beds of similar age from all other parts of Southern Russia. They are divisible into two groups: the lower, consisting of clay-slates and iron quartz-schists; and the upper includes carbonaceous shales free from quartzite, and so-called "decomposed schists." The rocks are much folded and show the effects of thrust, moreover, at many localities eruptive dykes and sills break through the crystalline schists.

The author mentions casually the occurrence on the right bank of the Inguletz, about 25 miles north of Krivoi Rog, of graphite-schists, and graphite-bands have been observed in the gneiss on the right bank of the Sholtaya.

The iron-ore deposits occur mostly in the lower of the two groups mentioned above, as by far the greater number of them are associated with the ferruginous quartzites. In the upper group, only a few isolated, unimportant deposits are found among the shales. The ferruginous quartz-schists, more or less thickly bedded, have a coloration which varies (according to their richness in iron) from a yellowish-white, through all shades of red, to a deep brown, and when fractured across they show very fine banding. The quartz is in the form of very small, water-clear grains containing opaque inclusions of iron-ore (magnetite, martite and hæmatite). Sometimes the quartz-grains are enveloped, sometimes in part replaced, by iron-ore. When the rock contains less than 40 to 45 per cent. of iron, it is not regarded as workable, and the local mining people call it "quartzite;" when it contains 45 to 70 per cent. of iron, it is properly termed "ore."

The type-form of the iron-ore deposits is lenticular in a horizontal plane, and wedge-shaped in a vertical plane: the length of a lenticle sometimes reaches 2 miles or more, its greatest breadth is some 450 feet, and the depth is about 230 feet. The ore consists mainly of hæmatite, in part pseudomorphous after magnetite (on an average, about 8 per cent. of the deposit is still unaltered magnetite, which sometimes shows polarity). Besides silica, and traces of lime, magnesia, manganese, etc., the ore contains so small an amount of phosphoric acid, ranging from 0·013 to 0·020 per cent., that it may be considered one of the freest from phosphorus in all Europe.

The poorer ores (40 per cent. of iron) are smelted on the spot by a French company, and another company is preparing to follow suit. Only the richer ores, averaging 60 per cent. of iron, are sent elsewhere for treatment. The following analyses convey some idea of their composition:—

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Iron ..	62·72	65·09	65·42	65·90	66·60	67·12	67·43	68·63	69·66
Silica ..	7·58	3·30	2·46	2·02	1·71	1·01	0·78	0·38	0·91

Russian geologists are not agreed as to the mode of formation of these deposits. Prof. Piatnitzky thinks that there was chemical sedimentation and simultaneous formation of the quartz and the iron-ores, while Prof. Kontkiewicz holds that the ferruginous quartzites are the result of the metamorphism of a sandstone.

Conformably resting upon these rocks are the carbonaceous shales already mentioned, which contain curiously-shaped, richly ferruginous concretions. These carbonaceous shales pass downwards into the so-called "decomposed schists," dark bluish-grey bands alternating with violet and red bands.

The author describes in some detail the deposits opened up in the various workings, and points out in conclusion that the total iron-ore production of the

district for the year 1896 was about 1,615,000 tons (100,000,000 pouds). He reckons the available quantity of ore at 19,345,000 tons (1,200,000,000 pouds), and, therefore, if this calculation be correct, the deposits would be worked out within the next 12 years. But, as most of the ore is the property of the Société Dnéprovienne, whose ground lease for their ironworks at Yekaterinoslav has to run for 36 years, and as they are only concerned to supply these ironworks, the probability is that the other mines will shut down before the 12 years are over, while the mines of the Société Dnéprovienne will work on for some 30 years yet.

L. L. B.

TESTS OF IRON-ORE.

(1) *Schmelz-Controlproben zu der Analysen der Eisenerze.* By FRANZ BETTGENBACH. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii., pages* 485-487.

(2) *Also comments on the above by an anonymous critic in the same volume, pages* 597-598.

The author has made more than 300 determinations of blast-furnace products in 45 years, and knows the value of a quick and easy method of analysis. For the metallurgist, it is rather a means of testing the material he is dealing with, than a scientific operation. Time is money with the practical man, and tedious methods should be avoided, for in many cases it is only rapid results which will explain a hitch in working, or a change in the quality of the products.

The difficulty of dealing with fluxes of 15 or 16 different kinds is increased by changes in the constitution of the ore, and the effect of the weather. The percentage of moisture in ores varies according to the state of the atmosphere from 5 to 30 per cent., and as furnace-charges are reckoned by weight, this must considerably affect the percentage of the different ores. If an ore which under normal conditions contains 5 per cent. of moisture, and 12 per cent. of silica, absorbs in variable weather 40 per cent. of moisture, it will then contain only 8 per cent. of silica. Coke also varies much in its percentage of water, limestone does not. Under these changing circumstances, it is impossible to calculate the composition of a charge upon the basis of a minute chemical analysis. For the practical metallurgist it is sufficient to analyse down to 1 per cent., although more delicate analyses are necessary to detect the presence of very small quantities of elements exercising a strong influence upon the products, such as phosphorus, copper, arsenic, etc. So much time and patience are, however, required for these processes that they have been discarded in favour of rapid empirical methods of determining the composition of an ore.

Among these one of the best is the Bertie process, in which the ore to be tested is smelted in a crucible lined with charcoal, a similar quantity having been previously treated with acids, to determine the solids to be converted into slag. From the result of these experiments, the amount of lime required in the flux is calculated, and the same slag obtained as it is intended to produce in the furnace. This method serves to check the results of chemical analysis, and the author has long used it with success. An advantage is that it can be employed by any iron-worker, without previous knowledge of chemistry, and the results are always available for subsequent examination. The method is as follows :—One or two grammes of dried and powdered ore are treated with hydrochloric acid, and

the insoluble residuum determined. An equal quantity is brought to a red heat in a platinum vessel, till its weight is constant, and the loss calculated. Ten grammes of the powdered ore are then mixed with as much powdered limestone as will form a flux, from which the slag is obtained. If accurate results are desired, the same proportionate quantity of coke ash should be added to the mixture as would be produced in the smelting. It is then placed in a crucible lined by ramming down into it charcoal powder mixed with water, and a hole carefully bored in the centre is filled with the mixture to be tested. The top of the crucible is closed, and sealed with fire-clay. It is then exposed for 1 hour or 1½ hours to the heat of a small gas or coke furnace, at white heat, allowed to cool, and the contents withdrawn. As a rule, the iron is found in buttons under the slag ; if there are any little pellets under the charcoal ash they are withdrawn with a magnet. The iron and slag are then cleaned and weighed, the former being weighed separately.

The following rough calculation is next made. It is assumed that the loss in the furnace of an ore thus tested is 20 per cent. ; the insoluble residuum is 15 per cent., and that 20 per cent. limestone is added, containing 50 per cent. of calcium oxide. The charge in the crucible is 10 grammes of iron and 2 grammes of limestone, or 12 grammes in all. Of this 20 per cent., or 2 grammes of water, carbon dioxide, etc., are lost in the furnace, and 1 gramme in addition, the carbon dioxide in the 20 per cent. of limestone. After smelting, the weight of the reduced iron is determined, and the oxygen required for its oxidation, which has escaped during the process, is calculated. Deducting all these from the 12 grammes composing the charge, the remainder ought to show the weight of the slag and iron after smelting. The absorption of carbon in the pig-iron may be neglected, as it only makes a difference of ½ to 1 per cent. in the total results, and this is compensated by a small quantity of iron in the slag. This process is quick, requires little skill, and is valuable for practical work. Of course the fluxes must be calculated by a practical metallurgist, but the actual process can be carried out by a skilled workman.

Ores containing much manganese require rather different treatment, because the manganic oxides are dissolved with the ferric oxide in the hydrochloric acid, and are found either in the slag or as reduced manganese in the iron. If they are to be transferred to the slag, the flux is so mixed that the acid element in it preponderates, and its increase in weight shows the proportion of manganese. If the latter is to be led into the iron, the flux is calculated for a basic slag, and an alloy of iron and manganese is the result, the increase in weight again showing the manganese. With iron-ore containing 2 or 3 per cent. of manganese, two tests may be made, the one for acid, the other for basic flux, and they ought to check each other. If the iron-ores contain lime their proportion of calcium oxide should be determined by treating 1 or 2 grammes with acetic or nitric acid. The loss shows the proportion of calcium carbonate or of magnesium carbonate to be taken into account, but this method is only required if the ore contains more than 3 per cent. For rapid and reliable tests, two or three crucibles should be used at the same time, and after a little practice the tests seldom fail.

This method of testing ores by smelting has the advantage of yielding the ordinary pig-iron of blast-furnaces. It is easy to mix the different ores in their required proportions, and if 20 grammes instead of 10 grammes are treated, the iron obtained is more readily worked up. In this case, a corresponding quantity of ashes from the furnace should be added. If the ores contain lead, it will all be found in the iron. With due care in making the tests as

above described, an error can scarcely occur. The composition of the slag can be determined, and the method will be found valuable by practical metallurgists and ironfounders.

This paper is commented upon in a later number of the *Zeitschrift* by a writer who considers that, besides a description of the time-honoured process of testing ore by smelting, it contains useful hints for practical metallurgists. It is not enough to know the percentage of manganese in an ore, in order to determine in what proportion this metal combines with the pig-iron. The chemical and physical properties of the manganese and ore exercise a great influence on the combinations of the former with the pig-iron. The proportions in which the two metals unite when smelted in a furnace cannot be determined by analysis, but according to Mr. Büttgenbach, a careful smelting test can make them known. If highly manganic iron is required, it is best to work with basic slag, and add as much lime as the mixture will bear. With certain ores this will transfer nearly all the manganese into the iron, but with others equally rich the process cannot be effected with even highly basic slag. The proportion can only be determined by the smelting test. Ten (or 20) grammes of the ore-mixture, carefully sampled and prepared, are mixed with the same proportional quantity of limestone flux as in the furnace, and the whole smelted in a lined crucible. If the proportion of iron in the ore-mixture has been previously determined by means of a standard solution of potassium permanganate, the iron after smelting will show an increase in weight; taking 1 per cent. of this increase as carbon, the rest represents the whole or part of the manganese, according to the quality of the manganic ore, and the resulting chemical compounds. Pig-iron may be thus obtained, containing 5 to 35 per cent. of manganese, and the results verified by chemical analysis. If on the other hand the proportion of manganese and iron in the ore-mixture is known, the proportion of manganese in the iron and in the slag can be calculated. These determinations are of special value at the present time, when ferro-manganese is so much in request. B. D.

VALUATION OF IRON-ORES.

Zur Berechnung von Eisenerzen. By G. Tleicher. *Stahl und Eisen*, 1896. *pages* 632-633.

The following is a universal formula for determining the value of any iron-ore:—

Let x, be the value of the iron-ore, free-on-board at the place of its production per 10 metric tons; f, be the freight to the furnace per 10 metric tons; e, percentage of pig-iron yielded by the ore; r, percentage of silica in the ore; k, percentage of calcium carbonate in the ore; C, price of coke per 10 metric tons at the place of its production; F, freight of coke per 10 metric tons; K, price of 10 metric tons of limestone delivered at the furnace; v, consumption of coke in decimals of a ton per ton of pig-iron; g, miscellaneous expenses, including wages, salaries, depreciation, interest, repairs, etc.; and P, cost of producing a metric ton of pig-iron, all prices, are given in shillings. The cost P is composed of:—

1. Cost of iron-ore: 10 tons of ore costing delivered $(x + f)$ shillings produce $e \div 10$ tons of pig-iron. The ore per ton of pig-iron will, therefore, cost $(x + f)$ $10 \div e$ shillings.

2. Cost of limestone: Each part of silica requires the addition of 2·5 parts of limestone less that in the ore. Hence 10 tons of ore require $(2{\cdot}5\ r - k) \div 10$ tons of limestone; or $e \div 10$ tons of pig-iron require $(2{\cdot}5\ r - k) \div 10$ tons of limestone, whence each ton of pig-iron requires $2{\cdot}5\ r - k \div e$ tons of limestone, costing $(2{\cdot}5\ r - k)\ \mathrm{K} \div 10\ e$ shillings.

3. Cost of coke: The ton of pig-iron requires r ton of coke costing $r\ (\mathrm{C} + \mathrm{F}) \div 10$ shillings.

4. Miscellaneous expenses g.

Therefore, $\mathrm{P} = (r + f)\ \frac{10}{e} + \frac{2{\cdot}5\ r - k}{10\ e}\ \mathrm{K} + r\ \frac{\mathrm{C} + \mathrm{F}}{10} + g.$

And solving with respect to r we have:—

$$r = \frac{\mathrm{P}\ e}{10} - f\ e - \frac{\mathrm{K}}{100}\ (2{\cdot}5 - k) - \frac{e}{10}\left(r\ \frac{\mathrm{C} + \mathrm{F}}{10} + g\right).$$

H. L.

KAOLIN AND CLAY-DEPOSITS OF NORTH CAROLINA.

Notes on the Kaolin and Clay-deposits of North Carolina. *By* J. A. Holmes. *Transactions of the American Institute of Mining Engineers*, 1895, *vol. xxv.*, *pages* 929-936, *with one illustration in text.*

In western North Carolina, indications of extensive dynamic disturbances and alterations of the rocks are found. Among the minor results of these changes have been the formation of numerous dikes or veins of exceedingly coarse granitic materials, which in some places are mined for mica and in others for kaolin. These dykes are filled with quartz, felspar, and mica in varying proportions, very coarsely crystallized. This felspar of the dykes undergoes, through the weathering action of the atmosphere, certain chemical changes, resulting in its alteration from felspar into kaolinite—the kaolin of commerce. These dykes vary in size from a few inches to several hundreds of feet thick and up to many hundred feet long. They are worked to a depth of from 60 to 120 feet, below which the original felspar has not been sufficiently altered, and is too hard for economic mining. The kaolin is crushed and washed in a series of settling-vats for the purpose of separating it from the granular quartz. Its plasticity is increased by the washing and subsequent grinding which it receives.

Deposits of kaolin material, which have clearly been carried some short distance, occur in many places, both in the form of arkose (where the kaolin is still mixed with the quartz and mica of the original granitic formation) and in the clay-beds, where it has been more completely sorted and the kaolin separated from the coarser materials, so as to form extensive beds of china or potter's clay. In some cases, in the arkose material, the partially decayed crystals of felspar are found with kaolinization incomplete, and mingled with fragments of other minerals, transported from the *débris* of crystalline rocks not many miles away. In many places, there are deposits of clay resulting from the decay of the granites, gneisses, and crystalline schists; these may be classed as partly residual and partly transported clays. They vary in composition with the character of the rocks from which they have been formed, and in colour from the presence of oxides of iron, organic matter, etc. They have been used in the manufacture of bricks, tiles, pipes, and fire-bricks.

The most extensive beds of clay are of the Lower Cretaceous (Potomac) formation; they are laminated, dark-coloured clays, occasionally highly lignitic and mixed with sandy partings. Limited exposures of siliceous Eocene deposits occur 5 to 15 feet thick, which have recently been tested for making fire-bricks with very satisfactory results. A. W. G.

MINE REGULATIONS IN THE BRESLAU INSPECTION DISTRICT, GERMANY.

Official Regulations. *Bergpolizei-Verordnung des Oberbergamts zu Breslau*, 1897.

Some changes and additions, of which the following are the main points, made on April 10th, 1897, in the Breslau general mine regulations, came into force on July 1st, 1897.

The air-volume supplied per minute to a fiery mine must be at least 70 cubic feet (2 cubic metres) per head of the largest number of men employed in an underground shift, a horse counting as four men; but a larger volume may be ordered in special cases. Two and a half times the above-named volume must be supplied for every man engaged in exploring or preparatory workings in virgin measures; but exceptions may be made for seams containing but little gas.

The scheme of ventilation must be such that as many as possible independent ventilation districts be provided with separate air-currents; and especially each level must be supplied with the necessary quantity of air by the shortest way, and always circulating in an ascending direction. Descending air-currents are only permitted in rises or dips driven upwards, or workings parallel with them, and in other workings exceptionally when not further used for ventilation, or when great thrusts render the keeping up of special return air-ways very difficult; and air which has already served for ventilation may be used for an upper level when the current is refreshed by a direct and uninterrupted supply of fresh air. No workings must be made before sufficient air-way connexions have been made; but the simultaneous driving of a road and air-way, forming a connexion with an upper level, may be permitted when the return-air from one does not pass over (or across) the working-place of the other.

In sinking shafts, the end of the brattice must never be more than 66 feet (20 metres) from the bottom of the shaft. Levels, cross-cuts, rises, and slants when the latter are more than 50 feet (15 metres) long, must have parallel air-ways, or be fitted with a tight brattice; and rises, and also slants when more than the above-named length, must be fitted with brattice, starting from the last connexion, even when there are parallel air-ways.

Fresh air may be supplied to working-places by (*a*) compressed-air pipes or (*b*) fans, which means must be employed when the permanent ventilation is not sufficient to prevent fire-damp accumulations; but hand-worked fans may only be used for separate ventilation in so far as they are employed exclusively for that purpose.

So far as may be required by special circumstances, while being compatible with safety, air-pipes or boxes may be used instead of brattices, provided the distance between the issue of the fresh air-current and the working-face does not exceed 13 feet (4 metres).

Hand-ventilators may only be used as accessories, for intensifying the ventilation or moving fire-damp accumulations; and they must be placed in the intake air-way, in such a manner that the return air-current cannot come into contact

with fresh air for the working-place. The ventilation may be effected by hand-worked fans alone, for stalls and air-way connexions, up to a total length of 130 feet (40 metres) and for other workings by written permission; but the same fan must not serve for more than one working-place.

Air-doors must close automatically, and those no longer required must be removed. A pair of interlocked doors must be provided in cases where the distribution of the air-current is liable to be unfavourably affected.

Shot-firing is only permitted in seams where fine dry dust is formed, even if there be no fire-damp, after thorough damping for at least 33 feet (10 metres) from the shot; and in such cases no black-powder or other slow explosive may be used, and high explosives only in safety cartridges.

In exploring and preparatory workings in an unwrought district, when coal is present in the cross-section of a heading, shot-firing is subjected to the above condition as regards damping, even when fire-damp and coal-dust are not present; and, immediately before a shot is fired, a careful examination with a safety-lamp must show that there are no fire-damp accumulations within a distance of 33 feet (10 metres).

The foregoing injunctions may be relaxed, subject to the approval of the mines inspector [illegible] in favour of individual seams, mine districts or collieries, on trustworthy proof being given that the coal-dust is, or has been rendered, free from danger; but coal-dust will only be considered free from danger when tests prove that it cannot be ignited in air containing 2 per cent. of gas by a blown-out shot of 17·6 ounces (500 grammes) charge, this proof being only admitted when the safety-lamps used indicate a 2 per cent. gas content in the mine atmosphere. J. W. P.

GENESIS OF LEAD-VEINS OF FREIBERG AND THE TIN-VEINS OF THE ERZGEBIRGE.

Beiträge zur Kenntniss der Freiberger Blei- und der Erzgebirgischen Zinn-Gänge. By DR. A. W. STELZNER. *Zeitschrift für praktische Geologie*, 1896, pages 377-412.

This article, although left unfinished at the death of Dr. Stelzner, is nevertheless deemed of sufficient importance to be published.

The labours of Messrs. v. Beust, Scheerer, and H. Müllen proved beyond doubt that in the Erzgebirge, as in other places, definite relations exist between the character of the mineral veins and that of their country-rocks, extending both to the mechanical process of the formation of the fissure and to the chemical process of its filling. In reference to the latter it may be borne in mind that the Freiberg veins are only rich in ore in grey gneiss, and poor or barren of ore in red gneiss.

Mr. Scheerer endeavoured to account for this phenomenon by the fact that the former gneiss contains 30 per cent. of an easily decomposable mica rich in iron, whilst the latter contains but 10 per cent. of a difficultly decomposable mica poor in iron, and he held that the first-named mineral when acted upon by mineral solutions readily gave rise to the formation of metallic sulphides, which the latter mineral was unable to do.

The above-named geologists were all advocates of the so-called ascensionist theory of vein formation; Messrs. Dieulafait and Sandberger about the ye[illegible]77 put forward energetically the lateral secretionist theory, which the latter w[illegible]

more especially supported by numerous analyses of the various silicates that form the mineral constituents of the various country-rocks, in the course of which analyses he found most of the heavy metals in these minerals.

The author points out that Mr. Sandberger's methods are not free from objections, and he carefully selected a series of Freiberg gneisses, and separated the mica from them by means of Prof. Thoulet's solution. The micas so obtained were then examined microscopically in order to make sure that they were reasonably free from enclosures and undecomposed. A series of analyses of these micas showed the presence of nickel, cobalt, tin, copper, zinc, lead, arsenic, but no silver, nor was it quite certain that some of these metals did not in some cases exist as minute disseminated particles of sulphides. If the veins obtained their metallic constituents from the micas of their country rocks, the author holds that they ought to occur in the vein stuff in the same proportion as they do in the mica of the rocks; the analyses of the latter show that it contains nickel and cobalt in far larger proportion than lead for instance, whilst the veins have yielded large quantities of lead, copper, silver, etc., with but comparatively small amounts of nickel. The author therefore concludes that the lateral secretion theory is not tenable as far as the Freiberg veins are concerned.

The granites of the Eibenstock and Schneeberg districts, with the existence of which the tin-bearing veins of those districts are connected was also submitted to analytical investigation in the same way. These veins contain cassiterite as the chief ore, scarcely any other heavy metals, lithia-mica, topaz, tourmaline and apatite, whilst the Freiberg lead-bearing veins contain chiefly ores of the heavy metals, only traces of tin ores, no lithia-mica, topaz, tourmaline, or apatite, and numerous carbonates, which are wanting in the first-named veins. Yet analyses show that the granites and the gneisses which form the country-rocks of the respective classes of veins, both contain the elements that enter into the composition of all the above-named minerals.

The author draws the following conclusions from the comparison of the analyses of these two rock series: —

1. Both in the granites connected with the tin-veins and in the gneisses that form the wall-rocks of the lead-veins the following elements exist as primary constituents, namely: —Lead, zinc, copper, cobalt, nickel, tin, titanium, silicon, barium, calcium and phosphorus, whilst the first-named contain in addition notable quantities of manganese, fluorine and lithium.

2. If the vein-filling were due to the infiltration of supage water traversing the country-rocks, similar vein-formations would be expected in both the above rocks.

3. But as the granites carry markedly tin-veins, whilst the gneisses carry lead-veins, the theory of the filling of the veins by the supage of surface water is open to grave doubts.

4. This theory fails to explain why the veins in both granite and gneiss contain no titanium minerals, why tinstone and apatite are found only in the one, lead-ore and barytes only in the other set of veins, whence the veins in the gneiss obtained the fluorine of their fluorspar and the sulphur of their sulphides and sulphates.

A satisfactory explanation is however afforded by the assumption that the contents of fissure veins have been brought up for the most part by deep spring waters from great depth, and only to a small extent have been obtained by leaching out from the country rocks. H. L.

OPEN-LAMPS FOR NON-FIERY MINES.

Neue Gruben-Lampen. By — ARK. *Siegener Zeitung, January* 5th, 1898, *page* 2.

Mr. Ark, of the Mühlenbach mine, Arenberg, near Ehrenbreitstein, has applied to miners' open oil-lamps, the central air admission which has given such good results in ordinary paraffin lamps. A small tube, passing up through the centre of the oil-vessel, constantly leads air into the middle of the flame, which is fed with oil by a circular wick surrounding the tube. The Physikalisch-Technische Reichsanstalt (section 2) states that the improved lamp with a flame 2⅜ inches (60 millimetres) high throws out horizontally 1·4 Hefner units, and that for 1 Hefner unit it only consumes about 0·33 ounce (9·2 grammes) of rape oil, while an ordinary lamp with similar height of flame only gives out 1·1 Hefner units with an oil-consumption of rather more than 0·35 ounce (10 grammes) per Hefner unit. A still further saving in oil is effected by the construction of the wick-holder, which prevents any scattering of oil if the lamp be swung in carrying. Furthermore, the combustion is nearly perfect, since a piece of white cardboard held at a slight distance above the flame is scarcely blackened, so that there is considerably less vitiation of the mine atmosphere. J. W. P.

LIGHTNING IN A MINE SHAFT.

Charbonnages d'Abhooz et Bonne-Foi Hareng, Siège d'Abhooz. Compte-Rendu des Jours de Mise. By E. FINEUSE. *Annales des Mines de Belgique*, 1897, *vol.* II, *page* 910.

On July 1st, 1897, a flash of lightning struck the iron pit-head only 52½ feet (16 metres) high, in preference to three neighbouring chimneys 80 to 130 feet (from 25 to 40 metres) high. Part of the electric current went down the winding shaft, which is tubbed with cast-iron rings and contains the pipes from the underground pumping-engine; and at the level of 690 feet (210 metres) it caused an explosion, without serious consequences, in the pumping engine-house, after which it became dispersed in the sump, at a depth of 1 300 feet (400 metres). The other portion of the current, which remained on the surface, passed along the wires for the electric bells and telephones, breaking and burning these appliances, and also throwing down the underground manager, who was near the mouth of the shaft, as well as four men engaged on the screens. J. W. P.

MAGNESITE-DEPOSITS IN UPPER STYRIA.

Neue Magnesit-Lagerstätten im Gebiete der Liesing und Palten in Obersteiermark, etc. By ED. DÖLL. *Verhandlungen der k. k. geologischen Reichsanstalt*, 1897, *pages* 329-331.

Four new localities have been discovered by the author within the past two years in Upper Styria for the occurrence of magnesite-deposits. The mineral is a pinolite, yellowish in colour, sometimes contains traces of talc, and appears in all cases to be associated with Carboniferous Limestone.

The author at the same time draws attention to the occurrence of rumpfite (a mineral first described in 1890) in connexion with magnesite, at the junction of carboniferous graphitic and chloritic schists with Carboniferous Limestone. There is now no doubt that rumpfite is derived from a highly ferruginous chlorite. In the Wald Pass it forms pseudomorphs after magnesite. L. L. B.

ORNAMENTAL MARBLE OF SAILLON, SWITZERLAND.

Sur une nouvelle Application des Marbres de Saillon et sur les Améliorations apportées à leur Exploitation. By Oscar Lavanchy. *Bulletin de la Société Vaudoise des Sciences naturelles, Lausanne,* 1897, *series* 4, *vol. xxxiii., pages* 231-234, *and* 1 *plate.*

This marble occurs in a workable thickness of about 50 feet, in six varieties differing in colour and markings, at the base of the mountains of the Grand Garde and the Tête du Bletton. It rests upon grits and shales of Carboniferous age, and is presumed to be Triassic, as it is overlain by an enormous mass of grey Jurassic limestones. Some of the marble is black, with yellow streaks ; some ivory-white ribboned, with green ; some grey-and-white ; some verd-antique, and so on. The workings are opened at an altitude of 3,250 feet above sea-level. Here is a bed of white statuary marble which it has been found difficult to quarry in large blocks ; but it will prove suitable for the manufacture of calcium carbide. The coloured marbles, on the other hand, are easily quarried in enormous masses.

For the last three years no resort has been had to blasting in these quarries, but the rock has been sawn *in situ* by the Thonard three-ply helicoidal steel-wire saw. The author describes and figures this ingenious apparatus, in which the sand formed by the rasping of the wire through the rock itself acts as the chief cutting agent. The marble is cut very clean, and can be delivered in sheets thin enough for making church-windows ! Slices of marble less than $\frac{1}{25}$ inch thick, closely applied to a sheet of ordinary glass, give tints of remarkable translucency and delicacy.

The helicoidal saw economizes a vast amount of time and labour ; and since it has been brought into use at Saillon there has been a great extension of the workings, and a brisk demand for the marble from Great Britain, the United States, and Germany. Worked by a benzine-motor of 4 horsepower, the saw will cut in 10 to 12 hours a trench 36 to 40 inches deep and 65 to 100 feet long. L. L. B.

CINNABAR-BEARING TUFFS OF MONTE AMIATA, TUSCANY.

Zinnober führende Trachyttuffe vom Monte Amiata im Südlichen Toscana. By Dr. Kloos. *Zeitschrift für praktische Geologie,* 1898, *pages* 158-163.

After a brief summary of the cinnabar occurrences in this district recorded by Messrs. Gerhard vom Rath, Primat, and Spirek, in their descriptions of the Diaccialetto (Siele) and Cornacchino mines, the author proceeds to describe the results of his own observations, made during a recent stay at Abbadia San Salvatore. Between that village and the eastern base of the mountain, a trachyte-cone some 5,600 feet high, extends an undulating terrace, some 3,000 feet above sea-level, strewn with great blocks of trachyte, and composed of loosely compacted beds of varying colour and structure. Under a lens, this loose material is seen to consist of worn-down sanidine-crystals, flakes of mica, and kaolin-like decomposition-products of the minerals which occur in the trachyte. These beds are all cinnabar-bearing, and in some cases contain so large a proportion of mercury that their red coloration and high specific gravity indicate its presence at once. Close to Abbadia, at the bottom level of the Fosso delle Lame, the Eocene limestones crop out, with a nearly perpendicular dip, from beneath these loose beds ; the latter are undoubtedly true eruptive products of the ancient volcano of Monte Amiata, of contemporaneous origin with the flows of trachyte.

Analysis showed that the felspathic sands contain percentages of mercury varying between 0·35 and 54·35, while a sample of kaolin was found to contain 4·8 per cent. of the metal. The decomposed trachyte itself, seamed by cinnabar-veins, contains as much as 5·36 per cent of mercury.

Forewinning has gone on in the loose beds to a depth of 100 feet or so from the surface, but they do not get richer as one goes deeper down. Exploration-work in the massive trachyte has been practically abandoned, for there seems no prospect of a sufficiently large amount of ore being found in it to repay working. Open-cast workings, however, in the tuffs and kaolin of the Lame terrace should prove very successful. A new company has been formed with this object in view, and they will make use of the recently patented Carmak-Spirek roasting ovens: these smelt ores with as low a percentage as 0·4 of mercury, at a profit.

Cinnabar occurs also in the Older Tertiaries (Nummulitic Limestone, Fucoid Shales, etc.) near Abbadia. The strike of these beds coincides with the prolongation of a line drawn through the old-established mines of Diaccialetto and Cornacchino. Intensely black shales, much decomposed, contain about 43·72 per cent. of mercury.

The author points out that the neighbourhood of Abbadia offers favourable opportunity for the further development of quicksilver-mining. From the village, a well-made road leads to the Monte Amiata railway-station, on the Siena-Grosseto line. The carriers can load about 30 iron bottles, each containing 76 lbs. of mercury, on to their low mule-waggons.

Turning now to the consideration as a whole of the cinnabar occurrences in the Monte Amiata district, they indicate the existence of several distinct systems of fissures, which are richest in ore at the points where they cross each other. The most important system of fissures runs approximately in a north-and-south direction, parallel to the main chain of the Apennines. The Nummulitic Limestones, Fucoid Shales, and Maiagno Sandstone, above which the cone of trachyte rears its mighty bulk, have all participated in the regional folding. After the folding and thrusting of the sedimentaries there came a time when streams of lava were poured out, and clastic eruptives showered down upon them. The cinnabar came in at a later period probably, condensing, perhaps, from acid vapours which found their way up through the fissures in the rock or concentrated from hot solutions. L. L. B.

NATIVE SILVER AND MERCURY IN THE SALA MINE, SWEDEN.

Fynd af gediget Silfver, Qvicksilfver, amalgam och Cinnober i Sala Grufva. By H. S. GREN. *Geologiska Föreningens i Stockholm Förhandlingar*, 1898, [illegible] *pages* 21-24.

Recently some old workings have been reopened in the Sala mine for the purpose of getting the zinc ore. In the last six months of 1897, the production reached 4,746 tons of ore, with a calculated percentage in the prepared stuff of 39 per cent. of zinc.

The native silver occurs in a grey fine-grained dolomite, in thin scales or flakes somewhat encrusted with sulphide: very little of it has been found in the crystallized condition.

Silver amalgam occurs, on the other hand, most often in crystals [illegible] druses in the dolomite. These are largely filled with quicksilver, which [illegible] adheres to the crystals of amalgam so tenaciously that it is with [illegible] separated from them.

The mercury occurs partly in small quantities filling hollows in the dolomite, partly in cracks and clefts in the rock, and also in the conditions mentioned in the previous paragraph. That mercury is a constant associate of the Sala ores is proved by the fact that when these were treated by the Russell process, about 1,320 pounds (600 kilogrammes) of it were got in 120,000 tons of ore.

Cinnabar is found in the dark grey serpentine schists which are associated with the dolomite.

The author gives a list of all previous references to the occurrence of silver, silver amalgam, and mercury in the mines of the district. L. L. B.

MERCURY ORES FROM CHINA.

Sur le Cinabre et l'Onofrite de Wen-Shan-Tchiang. By P. Termier. *Bulletin de la Société Française de Minéralogie*, 1897, *vol. xx.*, *pages* 204-210, *with two cuts in the text.*

The author examined and analysed some fine specimens of cinnabar-crystals and granular onofrite, brought by a French mining engineer from the mercury mines of Wen Shan Chiang, province of Kivei Cheń, Central China.

The cinnabar occurs in good crystals, and the onofrite as black patches, with a granular and lustrous fracture. Their chemical composition is as follows:—

	Cinnabar.	Onofrite.
Mercury	85·75	77·3
Sulphur	13·70	10·3
Selenium	Nil.	8·4
Zinc (with traces of iron)	—	1·3
Totals	99·45	97·3

In druses in the quartz-veins, the cinnabar crystals attain a length of nearly 1 inch, and they are surrounded and often pierced by fine needles of quartz. The remainder of the paper is devoted to crystallographic considerations.

L. L. B.

ELECTROLYTIC SEPARATION OF SILVER-LEAD ALLOY AT FRIEDRICHSHÜTTE.

Die Friedrichshütter Versuchsanlage zur elektrolytischen Scheidung von Zink-Silber-Legirung. By Ernst Hasse. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1897, *vol. xlv.*, *pages* 322-333.

The zinc-silver alloy is obtained by desilverizing lead by a modification of the Rössler-Edelmann process, the contents of the crucible being stirred with a rapidly revolving screw in such a manner as to force the zinc downwards through the lead but without disturbing the surface: in this manner the oxidation of the zinc is reduced to a minimum, and the stirring occupies only 10 to 15 minutes instead of 1¼ to 1½ hours as formerly. By adding a small proportion of chlorides, during liquation, in order to recover the final traces of metal, a pulverulent residue is obtained amounting to less than 1 per cent. of the total lead and forming the sole intermediate product containing silver.

A dynamo, capable of developing a 320 ampères by 15 volts current under 8 horsepower and 1,300 revolutions per minute, supplies the electrolytic energy to the vats which are made of 1 inch pine, 70 inches long by 26 inches wide and 27

inches deep, lined with sheet lead protected by thin boarding. There are eight of these vats grouped into two batteries. The electrolyte after issuing from the vats trickles down a series of steps, a more intimate contact with air being thereby occasioned than is possible in an air-blast agitator. The presence of zinc oxide and zinc scraps on the steps facilitates the purification of the lye by precipitating the foreign metals.

The anodes are formed by casting the zinc-silver alloy into plates, about $\frac{1}{3}$ inch thick and weighing 45 to 65 lbs., containing about $78\frac{1}{2}$ per cent. of zinc and 11 to $12\frac{1}{2}$ per cent. of silver.

Thin sheets of electrolyzed zinc deposited on rolled zinc plates form the cathodes, and a solution of zinc sulphate is used as an electrolyte, the most suitable strength for this being 1·140 to 1·160 degrees Baumé. The best working temperature is between 15° and 20° Cent., for, although at higher temperatures the operation is more rapid, the deposited zinc is so porous as to require re-melting.

A current density of 80 to 90 ampères per square metre of cathode surface, necessitating an electro-motive force of 1·25 to 1·45 volts per cell, is employed.

The zinc cathodes are melted down into plates of about 9 pounds weight, whilst the anode sludge is drawn from the vats at frequent intervals and treated for the recovery of the silver. To this end, the sludge is heated to redness for a short time, whereupon the sulphatic salts present combine with the silver to form silver sulphate, which is then extracted by lixiviation and the pure silver precipitated by means of scrap iron.

Copper is recovered from the residual sludge by solution in sulphuric acid, the traces of silver in the liquid being thrown down by scrap copper, and the copper precipitated by iron as cement-copper, which is of high purity. C. S.

EARLY COAL-MINING IN EUROPE.

(1) *Der erste Steinkohlen-Bergbau in Europa.* By FRANZ BÜTTGENBACH. *Aachen, Ignaz, Schweitzer*, 1898.

Hitherto the honour of first working coal has been attributed to the blacksmith Hullos (from whose name the French word *houille* is supposed to have originated), at Plennevaulx, now Coche, near Liége, in the year 1198; but the author brings forward documentary evidence to show that coal was worked so early as 1113, or 85 years previously, at Kirchenrode, now Kirchrath in German and Kerkrade, Kerkraade or Kerkraede in Dutch, situated in what is now the province of Limburg, Holland.

In 1104, the family of Saffenberg, which was connected by marriage with the house of Limburg, gave part of their Rhode estates to an Augustin monk named Ailbert, who built a monastery, that soon became an abbey, near the Castrum Rhodense, now Herzogenrath, calling the monastery Klosterrode and the parish Kirchenrode. The parish extended on the east to the River Worm, that flows through a valley on the sides of which the Coal-measures crop out, with seams from 2 to 4 feet thick, which must then have been evident to all, while the most prominent eminence now bears the name of Kohlberg (coal mountain). The abbey archives expressly state that coal was worked at Rhode so early as the year 1113, and that the abbots applied it to their own use and also sold it.

From that time forward, the places where coal was dug were called *kalkuln* thus spelled in the Latin text of the *Annales Rhodenses* 1113. *Kohl*

signifies in the local dialect (as also in that of Aachen or Aix-la-Chapelle) any excavation made in the ground; and coal is there called *koal*. Even at the present day a coal-mine is called by the inhabitants *koalkul* or more simply *kul*[1] (pronounced with the same sound as the English "full"); and this explains the word *kulcken* as it was written 785 years ago, and as it always recurred in the archives during a period of seven centuries.

The statement that digging for coal began so early as the year 1113 is therefore unquestionable, concludes the author; and the later archives affirm that the getting was continued uninterruptedly from 1113 to 1795, when the monastery was suppressed.

2) *Geschichtliches über die Entwicklung des 800jährigen Steinkohlenbergbaues an der Worm.* By FRANZ BÜTTGENBACH. *Igner Schweitzer, Aachen*, 1898.

The mining operations shown by the author to have been carried on for nearly 800 years were in the valley of what bore the name of Worm for a thousand years until about 1870, when it was without reason altered to Wurm. In a former work* he asserted that 785 years ago, that is about 1113, coal was known and mined in the Worm district; and he now observes that some old documents to which he has had access are so worded that the first winning of coal must be considered to have occurred at a still earlier date. Indeed this is manifest from the circumstance that the portion of the annals of the Klosterrath Abbey, which was already written in 1113, states, with respect to combustible mineral, that the abbots acquired parcels of land in places where coal occurred, which they designated by the name of *kalkulen*.† During the period between 1114 and 1122, on the occasion of a donation to the abbey, it is recorded that the property presented consisted of 15 joch or acres, and was situated near *Kalkulen* (or coal-mines); and at the very place thus designated coal-seams crop out to the surface. The author concludes from the above, and other passages which he quotes, that there can be no doubt about digging for coal (but all for the abbey on the left bank of the Worm) having been carried on in many places, and that therefore coal was already commonly known, won and consumed before the year 1113 in the Worm district. Moreover, such passages may be found throughout the whole course of the annals up to 1698, thus removing any doubt that coal was worked uninterruptedly during the period in question. J. W. P.

WORKING THIN FLAT COAL-SEAMS.

Abbauverfahren auf flachen [illegible] Flötzen. By H. GUTMANN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 59-63.

The author considers that the longwall system is of questionable utility, especially in the case of flat seams, when worked outwards, since the necessity for conveying the coal through gob-roads involves the passage of the ventilating current through the goaf, whereby it absorbs fire-damp from the latter and increases the danger of explosion and the production of gob-fires. To reduce these risks to a minimum, it is essential that the coal between the face and the main-roads should be disturbed as little as possible before being taken out, an object best effected by driving a minimum number of headings to the boundary and working homewards, keeping the face in a right line and providing for a con-

* See No. 1, *ante*. † *Ibid.*

centration of labour, so that the face may move too fast to allow the goaf time to heat before packing. The face-line should be in a direction diagonal from the roadway towards the boundary, and not parallel to the former; by this means the ventilation of the face is simplified, and the working roads being only driven as required for taking out the coal, the expenses are considerably less than in the parallel system of working homewards. All ways not actually in use are boarded up to exclude the air, which, therefore, takes the shortest possible route along the face. For thin, flat, or slightly inclined seams, where the roads and ways have to be driven through dead-ground, the coal-pillars are divided by levels about 200 feet (60 metres) apart up to the face, where they are again subdivided into working pillars some 40 to 50 feet (12 to 14 metres) wide, the diagonal straight line of the face being composed of a number of steps. With this arrangement, two men can hew at each side of the pillar and the face be moved at the rate of 20 inches a day in a seam 40 inches thick. The coal is conveyed from the face to the inclines, and thence to the roadway. An airway must be kept open along the face between each two steps, the timbers of this and the ways being recovered as the face recedes, so that the goaf falls in and the air-current does not pass through it.

When the dip of the seams is greater, the same form of step-working can be carried on by driving levels from the inclined hauling-way, as required, up to the face. The greater the number of steps in each pillar the quicker the working, but the limit is soon reached, and it is found better to make five the maximum in pillars of the above dimensions. The face, in such event, moves at the rate of 15 inches per day. Wider pillars are not recommended, owing to the extra labour involved when the coal has to be shovelled or carried more than 20 or 25 feet to the headings. When the area of the workings is large, it may be divided into sections and worked on the same plan, with, of course, the necessary alterations for ventilating with a separate air-current. C. S.

WORKING SWOLLEN-OUT COAL-SEAMS.

Charbonnages [illegible] Exploitation [illegible] By J. DE LAIR. [illegible] 1898. [illegible] pp. 153.

When the sharply-inclined portion of the Grande Séreuse coal-seam was being worked at the level of 1,700 feet (520 metres), two horizontal portions of slight length were encountered where the seam had been turned over so that the geological roof became the actual floor; and at the bends of the seam the coal was found to attain a thickness of 10 to 13 feet (3 to 4 metres), which rendered its working difficult and the timbering costly. Moreover, the actual roof (geological floor) consists of a bed of rotten clay-shale varying from 5 to 6 feet (1·5 to 2 metres) in thickness; and it became necessary to take the greatest precautions for preventing falls, which under the circumstances would soon give rise to heating and underground fires. The measures adopted, which generally answered well, for taking out the coal without heating, so as to avoid spontaneous combustion, comprised the winning of the mass by vertical stopes, taken one after the other in a downward direction. The seam being vertical, each stope had the width of the seam or 6½ feet (2 metres), and a height of 13 feet (4 metres). Where the coal had to be left in, iron rods were driven at intervals for giving early warning of increased temperature in the mass. J. W. P.

SERVICE RAILWAY FOR THE SAINT ETIENNE COLLIERIES.

Description de la Construction d'un Chemin de Fer de Surface à Voie de 1 mètre et de l'Installation d'une Carrière Centrale de Remblais pour la Société Anonyme des Houillères de Saint-Etienne, Loire. By — PERRIN. *Bulletin de la Société de l'Industrie Minérale*, 1897, *vol. xi., pages* 5-154.

This company, which was among the first to adopt the method of working by large stalls completely gobbed, now works seams averaging 18 feet in thickness, but slightly inclined, containing much gas, and having a very insecure roof, so that underground fires readily occur, and it is necessary to gob the workings as thoroughly as possible by rock let down from the surface. Complete gobbing with a due proportion of pack-walls to loose filling is also necessary in the working of thick seams by falling stopes, so as to permit of passing underneath for getting the stope below. From the commencement of working the coal, therefore, quarries were required for yielding the gob-material, which is required to the extent of about half the quantity of coal worked, and let down by the upcast shafts.

There are four main pits, each with its screening-plant, washing-floor, coke-ovens, and briquette works, all connected by private branches with the Paris-Lyon-Méditerranée main line of standard gauge. The collieries are so near the city of Saint Etienne that they have gradually become surrounded by buildings; and it was therefore found impossible to extend the gobbing quarries as they became worked out.

The small coal was formerly conveyed from the winding shafts to the coke-ovens and briquette works in railway waggons at a very heavy cost for short distances, because part of the route was over the railway company's lines; and so early as 1880, the project was formed of making a 2 feet line for hauling the mine tubs directly. When the necessity of procuring gob-material from fresh sources became imperative, the project was revived; and, in 1890, a definite scheme was drawn up to fulfil the following conditions:—Starting from the new gobbing-quarry, the line must serve (1) all the gobbing-shafts; (2) the coke-ovens and briquette-works; (3) the timber-yard; and (4) the central depôt and workshops; while (5) the line must be kept in tunnel under one district of the city so as to avoid level-crossings; and (6) be as far as possible on the company's land; while (7) the quarry selected must furnish sufficient gob-material to last for the working of the collieries, and send on an average 1,300 tub-loads daily to the gobbing-shafts.

Trials, however, of hauling the mine tubs in sets of 50 or 60 at various speeds showed the impossibility of thus supplying the pits with gob-material; and ultimately the gauge of $3\frac{1}{4}$ feet (1 metre) was chosen, with trucks each carrying 6 tubs. In 1891, the site of the quarry was selected, and the project definitely settled. The survey was begun in January, 1892, and the works started in the following August, being finished in January, 1896, this limit being fixed by the rapid exhaustion of the existing gobbing-quarries. The trace of the line was fixed by the levels and positions of the pit-mouths and of the works where loading quays were required, while several streets and also 27 lines had to be passed under, with the minimum thicknesses stipulated to be left. Level-crossings were out of the question; and the line had to be kept as far as possible on the company's land, for avoiding purchase and also surface damage, while the minimum radius of curves was fixed at 164 feet (50 metres), and the maximum gradient at 1 in 50. Care was taken in the longitudinal section to avoid sudden transitions from a rising to a falling gradient.

Quays for loading and unloading the tubs, carried on the trucks, were formed at each of the shafts or works. Each line of 3¼ feet gauge abuts on a quay for giving and receiving the tubs, while presenting a longitudinal section so that, on the line of the full tubs, the train drawn up for unloading is on a gradient falling towards the quay, so as to permit the tubs to leave the carrying trucks and run on to the quay by gravitation ; and on the contrary, on the empties' line, the tubs that have to pass from the quay on to the carrying trucks run down of themselves. Moreover, the piece of line abutting on the quay for receiving the train has three different gradients in order that the forward tubs, pulling upon those in the rear which resist this influence, shall draw the chains taut while facilitating the passage of the tubs over the points and preventing their running off the line. The trains, 95 feet (29 metres) long, including the engine, consist of 6 trucks, carrying 36 tubs.

There are altogether nine termini, as they are called, including eight for serving the gobbing-shafts, workshops and depôts, and one for forwarding gob-material, that of the new quarry at Éparre. During the year ending with September, 1897, the distance run over was 24,209 miles (38,960 kilometres) ; and the 8,009 trains carried 288,324 tubs, or 961 tubs daily. The working expenses just exceeded £1,000 (25,000 francs), showing the mean cost for conveying a tub of gob-material from the quarry to the shaft, including the quarry expenses, to be a little over one penny (11·5 centimes). J. W. P.

SCHAUB ELECTRICAL COAL-CUTTER.

Schlitz und Schrämmaschine mit Elektrischem Antriebe (Patent Johann Schaub). By V. Waltl. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 677 *to* 680.

The Schaub machine cuts a couple of vertical slits in the face of the coal by means of bits mounted in frames which have an alternate and reciprocal motion, being raised and lowered in their guide-frames by racks and pinions reversing automatically at the termination of each stroke.

The apparatus is mounted on a truck for convenience in transit, and the motive power, furnished by an electric-motor, is transmitted by cog-wheels and chain-gearing to the boring spindles carrying the bits, the chains being kept taut by weighted toothed rollers on the fixed frame. The up-and-down movement of the boring-frames is secured by a transverse arm driven by spur-gearing from the motor-shaft and terminated at each end by a pinion actuating the boring-frame rack. Each frame, as it nears the bottom of its stroke, depresses a projecting lever arm which moves a slotted quadrant and thus alters the position of a coupling-clutch at the centre of the cross-arm, thereby releasing one of the spur-driving wheels and engaging the other (both being mounted loose on the arm), so that the motion of the arm is reversed, and consequently the motion of the frames also.

By means of a hand-lever and worm-gearing on the bed-plate the horizontal distance between the boring frames (and size of block cut) can be adjusted within certain limits ; and the frames being hinged, the machine can be turned within a narrow space. C. S.

NADORITE-DEPOSIT IN ALGERIA.

Sur le Gisement de Nadorite d'Algérie. By L. Gentil. *Bulletin du Muséum d'Histoire Naturelle*, 1897, pages 258-260.

In a zinc mine in the province of Constantine occurs the chlor-antimoniate of lead known as nadorite (from Jebel Nador): this occurrence is so far unique. The nadorite forms the gossan of a considerable vein of zinc carbonate worked by the Vieille Montagne Company: it is in fine brown flakes which decompose to a [illegible]-yellow. Associated with it are cerussite, galena, blende, calamine, etc.

The vein of zinc ore traverses red conglomerates, and white marls and limestones of lacustrine origin, of Oligocene and, in part, Lower Miocene age. The ore lies lodged in a great mass at the junction between a marl bed and the overlying limestone. The sedimentary rocks have been apparently much altered by the contact of the vein—the marls receiving a variegated coloration, and the lacustrine limestone being highly impregnated with zinc. L. L. B.

ORIGIN OF PETROLEUM.

Versuch einer Theorie zur Erklärung der Entstehung des Petroleum-Vorkommens. By Dr. Rudolf Zuber. *Zeitschrift für praktische Geologie*, 1897, pages 84-94.

The author, now a professor at the University of Lemberg in Galicia, has for the past 17 years made a study of petroleum-deposits in the Old World and the New. He summarizes as follows the geological conditions of all the known occurrences:—

1. Fossil hydrocarbons, and especially petroleum, are found in strata of very different geological age; but, in each oil-field, in groups of rocks characteristic for that particular region, of sedimentary and almost exclusively of marine origin.

2. Oil-bearing strata of all ages and localities show so startling a resemblance in formation and composition that we may fairly speak of the petroliferous facies of various rock-systems. Mostly we find bituminous shales and varicoloured clays interbedded with sandstones and conglomerates. The limestones which are sometimes associated with these contain, as a rule, bituminous substances, but hardly ever any petroleum properly so-called. Whenever fresh-water formations are intercalated among the foregoing they are very seldom bituminous. Some of the Palæozoic oil-bearing strata of North America are very similar to the Jurassic petroleum-shales of North Germany and the Eocene rocks of Galicia. The Upper Triassic or Rhætic petroliferous strata of Western Argentina are, for all practical purposes, identical with the Oligocene of the Carpathians, so too are the oil-bearing sands of Baku and Boczky.

3. Great quantities of petroleum occur in very thick beds of sandstone. Natural wax (ozokerite) is known to occur only in nests and fissures in the younger Tertiary clays. Bitumen and asphalt are found in limestones or as the residue of weathering and evaporation of fluid petroleum.

4. Where several petroleum-formations of different ages occur side by side, groups of strata absolutely free from bitumen are intercalated conformably between two oil-bearing groups – as, for example, in the Eastern Carpathians, the Jamna sandstone which separates the Cretaceous Ropianka series from the Eocene.

5. Volcanic phenomena, properly so-called, are nowhere known to be connected with petroleum-deposits. The author points out that the gas-wells and mud-

geysers of Rumania, Kerch, and Baku have nothing whatever to do with volcanicity. So far indeed from inducing the occurrence of petroleum, volcanic outbursts check it when they do not annihilate it.

6. Salt-deposits, saline and sulphuretted-hydrogen springs are an accompaniment of nearly all the known oil-wells.

7. Various strata yield various qualities of petroleum.

These facts established, the author proceeds to discuss the many hypotheses which have been put forward regarding the origin of petroleum. First of all, he dismisses the emanation theory as based on too large a generalization, and as not quite consonant with the available evidence. He holds that the only theories worth considering are those which postulate the formation of the petroleum within the very strata which now contain it as a decomposition-product of organic substances. He criticizes at great length the Höfer-Engler hypothesis of the purely animal origin of petroleum, and shows that, so far from confirming this hypothesis, the palæontological evidence of the deposits themselves distinctly contradicts it. Plant-remains are more abundant than those of animals in the paraffin and petroleum-bearing rocks of Saxony and the Carpathians, of Pennsylvania and Argentina. Further, the author holds that in a few cases petroleum was formed at normal, or slightly higher than normal, temperatures, but under enormous pressure; although he does not believe that this convenient hypothesis of high pressure with low temperature will apply to the majority of occurrences. He draws attention to the little-known experiments and analyses made by Dr. Radiszewski among the oil and natural-gas wells of the West Galician Carpathians. These lead inevitably to the conclusion that petroleum is a product of the putrefactive fermentation of drifted plants buried in marine silt. The mixture of animal remains with these, as well as of other vegetable bodies, giving rise to different decomposition products, would help to account for the difference in composition of the various petroleums. Finally, the author sums up his views as follows:—

1. Fossil hydrocarbons are of organic origin, arising in part from plant-remains; in part from animal-remains.

2. The chief chemical reactions which condition their formation are the putrefactive decomposition of animal and vegetable fats after elimination of albuminoids and the putrefactive fermentation of cellulose.

3. The presence of sea-water salts has in part had a preservative effect, but has probably influenced the formation of solid and fluid hydrocarbons (natural wax and petroleum), whereas in the presence of fresh water various gases and coal-seams would be formed.

4. The most favourable geological conditions were doubtless found in deep tranquil bays, wherein great accumulations of organic matter were immediately covered up by precipitated sediments. (A recent example is the Gulf of Karabugas, in the Caspian.)

5. Most petroleum-deposits are of primary origin. It is only very locally that the oil has travelled from its original *locus* into neighbouring porous and fissured strata. The first part of the process of formation probably took place mainly in clays and shales, while the finished product naturally accumulated in the interbedded sandstones.

6. Natural wax (ozokerite) arose under similar conditions and simultaneously with petroleum; and under certain circumstances, it passed partly or wholly into petroleum. L. L. B.

PETROLEUM DISTRICT OF KÖRÖSMEZÖ, HUNGARY.

Das Petroleumgebiet von Körösmezö (Marmaros). By Dr. Theodor Posewitz. *Mitteilungen aus dem Jahrbuche der kgl. Ungarischen Geologischen Anstalt*, 1897, *vol. xi.*, *pages* 301-308, *and one map.*

The oil-bearing strata are of Middle Eocene (early Tertiary) age, and consist of pale-grey, finely micaceous thin-bedded sandstones, veined here and there by calcite; then come grey marls and dark clay-slates which are interbedded with a highly micaceous, rotten, bituminous sandstone. The last-named occurs at a high horizon, generally in the middle of the basin, while the first-mentioned sandstones occur at the edges of the basin. Numerous folds characterize this series of rocks.

Within the last 20 years, several companies have put down borings, four of which only have been carried to any considerable depth, but the results so far are unpromising. Down to 780 feet, no great quantity of petroleum is available, and in order to ascertain whether it occurs in workable quantity lower down, one would have to bore through the entire Middle Eocene series. The disturbed condition of the strata does not permit of an exact estimate being made as to the depth this would imply, but it could hardly be less than 1,600 feet. The author thinks that a test-boring should be put down opposite Lopusanka, at the Bubna ridge, in the neighbourhood of an anticlinal. The positions of all the borings are shown on the geological map which accompanies the paper. L. L. B.

DISCOVERY OF PETROLEUM IN THE WESTERN CAUCASUS.

Sur de nouvelles Sources de Pétrole au Caucase. By — Venukoff. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvi.*, *page* 1740.

On May 14th, 1898, researches conducted by a Russian mining engineer and a French bank agent resulted in the proving of sand-beds soaked with naphtha in the neighbourhood of Anaclia in the Western Caucasus. Tho water which accumulated in the preliminary excavations soon became covered with a layer of liquid naphtha. It is proposed to start boring at once, and it is expected that Anaclia is destined to prove a formidable rival to Baku: its situation on the Ingur, near the point where that river opens into the Black Sea, makes it much more accessible to European trade than the famous petroleum-city on the Caspian. The landowner is the Prince of Mingulia, and the rights of working the oil-wells have been conceded to Mr. Mindovsky, a Moscow capitalist. L. L. B.

GROSNY (CAUCASUS) NAPHTHA-DEPOSITS.

De Wladikawkaz aux Gisements de Naphte de Grosny. By A. Konchin. *Guide des Excursions du VII. Congrès Géologique International, St. Pétersbourg*, 1897, *No. xviii.*, *pages* 1 *to* 4, *with section in text and map.*

The naphtha is worked in two deep ravines which cut across the anticlinal fold forming the Grosnensky ridge. In the western ravine are brown naphtha-bearing shaly clays, but the chief deposit, 1,400 feet thick, is lower down. It consists of Paleocene friable quartzose grits, very porous, alternating with finely-laminated dark brown shaly marls. The productive beds are overlain by a barren series of clays and sands, 600 feet or so thick, also Paleocene: this covering has been eroded off some portions of the anticlinal, and so the naphtha springs come to day.

Some idea of the wealth of the deposit is conveyed by oil-well No. 7, in the Akherdow property ; it has been opened for 18 months at a depth of 450 feet, and has already yielded more than 645,000 tons (40 million pouds) of naphtha.

Some 2 miles west of this, in the Mamakievskié ravines, are several natural gas and oil-wells, associated with sulphurous thermal springs. Here, and in the Nephtianka river-valley, the same Paleocene rocks occur as those above described ; but in the last-named area they are overlain by Neogene and alluvial deposits. Other thermal springs and natural gases well out from either side of the Tersky ridge, also from an anticlinal of Paleocene rocks (compact quartzose grits).

L. L. B.

GEOLOGY OF THE BAKU NAPHTHA-DEPOSITS.

De Tiflis a Bakou : Gisements de Naphte de Bakou. By A. Konchin. *Guide des Excursions du VII. Congrès Géologique International, St. Pétersbourg,* 1897, *No. xxiv., pages* 1 *to* 5, *with map and sections in text.*

The peninsula of Apsheron upon which Baku is situated is made up of :—

1. Post-Tertiary deposits, consisting of loess, clays with *Cardium catillus*, gravels, pebble-beds, shelly littoral sediments, with all of which are mingled the ejectamenta from mud-volcanoes and naphtha oxidation-products.

2. Tertiary deposits consisting of :—(iii.) Upper and Lower Aralo-Caspian Neogene, shelly limestones, sands, clays, and grits ; (ii.) Oligocene naphtha-bearing sands, also water-bearing and dry sands, grits, and clays ; (i.) Upper Eocene marls and shales with fish-remains.

The Oligocene beds form an anticlinal fold of low arch, whose axis, dipping slightly from the north-west to south-east, runs from Balakhany to the Ramaninsky Lake. The naphtha-bearing series, the summit of which crops out near the former locality, dips, therefore, gently towards Ramany, and, farther on, towards Surakhany. There it disappears beneath barren, greenish, and brown clays, which are interbedded with water-bearing sands and overlain by Aralo-Caspian limestones.

The naphtha-bearing beds which crop out between the Bog Boga ridge and the salt lake of Biukshor are seen to run from west to east along the Sabunchinsky and Ramaninsky Lakes. Then they bend round northward, and finally north-westward, from Ramany to Zabrat. The area richest in naphtha is a triangle of about 3,000 acres (10 square versts), lying between Balakhani, Sabunchi, and Ramany. The limbs of the fold, one extending from Sabunchi to Biukshor, the other from Ramany to Zabrat, become poorer in naphtha the farther one gets away from the central portion of the deposit. The total thickness of the naphtha-bearing beds varies from 300 to 750 feet at Balakhany, and reaches 1,500 feet at Ramany and Sabunchi. The deposit comprizes many horizons of rich naphtha-bearing sands, between which are intercalated beds of clay impermeable to gases and naphtha. Around the triangular area above-mentioned, the Aralo-Caspian limestones form a sort of belt, but between Ramany and Surakhany they have been less affected by erosion, and cover the surface. Near the last-named locality the presence of the naphtha-deposit made itself known by means of several powerful gas-blowers coming up through fissures in the rocks.

Three miles south of Baku, on the shore of the Caspian, the little oil-field of Bibi Eibat occurs in a small erosion-valley of the Oligocene strata. The structure and character of the rocks are essentially identical with those described above.

L. L. B.

COMPOSITION, DEPOSITION, AND FORMATION OF PHOSPHATES.

Sur les Variations observées dans la Composition des Apatites, des Phosphorites et des Phosphates Sédimentaires: Remarques sur le Gisement et le Mode de Formation de ces Phosphates. By ADOLPHE CARNOT. *Annales des Mines*, 1895, series 9, vol. v., pages 137-231.

There still remain many controverted points in connexion with the formation of natural phosphates of lime; and it may be of use to bring together in this paper some new observations as to the various deposits of phosphates, variations in their composition, especially as regards their fluor-content, and also the conclusions to be drawn therefrom respecting the mode of their formation, while passing successively in review (1) crystallized phosphates or apatites; (2) concretioned phosphates or phosphorites; and (3) sedimentary phosphates.

(1) It is generally admitted that, in apatites, phosphate of lime is always associated with a constant proportion of fluoride or chloride of calcium, these two compounds being susceptible of mutual substitution in the proportion of their atomic weights; and the author's study of lime phosphates has led him to make a detailed analysis of fifteen samples of apatite of various origins, which have in most cases proved the correctness of Mr. Rose's formula. He met, however, with some anomalies which he describes, with the variations of the substances from pure and exclusively fluorated apatite.

(2) Phosphorites are specially characterized by their concretioned structure, while their texture is in some cases apparently compact and in others visibly fibrous. Their colour is sometimes uniform, white or yellowish-white; but very often the successive zones are differently tinted, the superposition of these zones clearly indicating the mode in which phosphorites were deposited; viz., in a similar manner to that of concretioned limestone. Samples were examined of very varied origin, some from the celebrated Quercy deposits in the French departments of Aveyron, Lot, and Tarn-et-Garonne, in which the zoned arrangement is very marked, and others from the deposits in the Gard, Hérault, and Aude, and also Oran in Algeria. The formation of certain aluminous phosphates, like those found in the caverns of Oran and Hérault, must be referred to the action of surface-water which has washed away the phosphated organic *débris*.

As to the mode in which phosphorites were formed, it is wellknown that they have always been produced by the solution and subsequent deposit of the substances composing them; but the author considers that this deposit cannot be attributed to mineral water issuing from great depths, the regular flow of which is scarcely in accordance with the frequently slight and very irregular fluor-content of the phosphorites. In his opinion, it is only in the case of apatites, crystallized or occurring in crystalline or fibrous masses, that the intervention of eruptive phenomena or thermal springs can be regarded as the originating cause.

The production of phosphorites more or less fluorated may often be explained by the action of fresh water on sedimentary phosphates or on fossil bones; and, moreover, the fluor-content may not have remained the same in the phosphorites as it was in the original phosphates. The decomposition of organic matter, of animal or vegetable origin, containing phosphorus, its transformation under the influence of oxidizing agents, and the reaction of the dissolved products on the rocks passed through or enclosing them, may also have given rise to a certain quantity of tricalcic, bicalcic or aluminous phosphates; but the latter are not fluorated, or only slightly so, because they owe their origin to substances almost exempt from fluor.

(3) In connexion with sedimentary phosphates, the author observes there is little doubt that living organisms, animal or vegetable, are capable of extracting and concentrating the phosphate of lime in sea-water ; but living creatures are not the only agents by which a segregation of mineral elements can be effected. In the same manner as dissolved silica, acting on fossil-remains in the midst of limestone beds of various age, has given rise to flint nodules, millstone grit, silicified wood and fossil shells, a large portion of lime-phosphate nodules consists of the mollusc shells or vegetable remains transformed and filled with phosphated matter.

A double set of experiments in this connexion led the author to conclude that there can occur in nature, on organic matters, the deposit of tribasic phosphate of lime, and that, upon the phosphate thus formed, calcium fluoride may be fixed. Moreover, there is no reason why these two phenomena should not have been manifested simultaneously, provided that the water contained both phosphates and fluorides, and that they therefore produced the same effect as a deposit of fluo-phosphate of lime ; but, instead of the constantly identical composition supposed by this hypothesis, the two independent actions of the phosphate and the fluoride, whether they be successive or simultaneous, may produce either fluo-phosphates, having the composition of apatite, or phosphates more or less fluorated than the crystalline compound. J. W. P.

ROTARY HYDRO-CYCLONE PUMP.

Nouvelle Pompe Rotative à Cyclone Hydraulique. By G. Trouvé. *Comptes Rendus Hebdomadaires de Séances de l'Académie des Sciences*, 1898, *vol. cxxvi.*, *pages* 1097-1099.

This appliance for raising liquids, which utilizes centrifugal force combined with a gyratory motion communicated to the liquid, consists of a trunconical portion made to revolve rapidly on its axis within a corresponding fixed portion having an inlet at the small end, while the outflow takes place tangentially to the largest portion of the cone. The useful effect of the hydro-cyclone, which participates in the action both of the centrifugal pump and of the exhausting tube, is increased by the addition, inside the truncated cone, of a helix, which, however, does not constitute an essential part of the appliance, as is proved by the following facts :—(1) Suppressing the helix makes no difference to the volume delivered, nor to the direction in which the liquid moves ; and (2) on the whole system being turned in the reverse direction, the volume delivered is considerable, notwithstanding the resistance opposed by the helix to the motion of the liquid. A hydro-cyclone pump of very small size is capable of delivering a considerable volume, both volumes and pressures, which depend upon the speed of rotation, being only limited by the strength of the appliance. With inlets and outlets of $10\frac{3}{4}$ square feet (1 square metre) sectional area, 11,000 gallons (50 cubic metres) of water may be raised per second. J. W. P.

ARRANGEMENT FOR CLEANING SAFETY-LAMPS.

Putzvorrichtungen an Grubensicherheitslampen. By J. W. Schiele. *Hüttenmännische Zeitung*, 1897, *vol. lvi.*, *page* 449.

In the safety-lamp described by the author, access to the glass-cylinder for cleaning the same is afforded in one type of construction by the gauze being continued on one side right through the cylinder down to the oil-vessel, the edges of this extension being packed gas-tight so that no fire-damp can pass through to the flame. A cleaning rag, etc., can be inserted in the space between the gauze-

extension and the glass-cylinder, and as the latter can be moved round by turning the ring on which it is mounted, the glass can thus be cleaned all round without opening the lamp.

In a second type of safety-lamp, the inside of the glass-cylinder is exposed by depressing the gauze so as to enclose the flame ; and the same result can also be attained by the converse means : viz., raising the cylinder. When this last arrangement is used, however, an extra cylinder of glass, metal, or gauze surrounding the oil-vessel and ascending with the lamp-cylinder, has to be provided for the protection of the flame. C. S.

SELF-LIGHTING SAFETY-LAMPS.

Expériences sur les Lampes de Sureté à rallumeur système E. Guichot : Rapport présenté a la Commission du Grisou. By G. Chesneau. *Annales des Mines*, 1897, *series* 9, *vol. xi., pages* 250-258, *with illustrations in text.*

In accordance with the standing instructions of the French Minister of Public-works, two types of self-lighting safety-lamps were submitted by Mr. Guichot to the Fire-damp Commission ; and they were tested in the laboratory attached to the Paris School of Mines by two apparatus which permit of examining, so long as may be required, the phenomena manifested by a safety-lamp, placed either in a mixture of air and fire-damp at rest or in one of air and lighting-gas moving at great speed.

An ordinary Boty lamp, fed with colza oil, is fitted with a lighting arrangement which consists of a round brass disc, in one side of which are seven radial recesses for holding wax matches (vestas), the disc and its accessories being contained in a brass case lodged in the oil-vessel in such a manner that the disc, at right angles to the top of the oil-vessel, projects the height of a match ; and, as the disc is rotated, the head of each match in turn is brought near the lamp-wick, the rotation being effected by a rod worked from the outside, and the ignition by friction against a steel rasp. The match burns sufficiently long to light a wick fed with colza oil ; and an ignition of an explosive mixture inside the lamp can only light one match at a time, the effect of which cannot differ greatly from that of the lamp flame.

Boty, Mueseler and Marsaut lamps, transformed for burning spirit, are fitted with a self-lighter, depending on the friction against a steel style of fulminate dabs of composition on a band of strong paper—which composition, though easily ignited by friction, is not readily inflammable in a high temperature merely. As regards relighting, this arrangement always gave good results ; and, placed in an explosive mixture of air and fire-damp at rest for $\frac{1}{4}$ hour, the lamp showed no signs of passing the flame outside. It might be feared that, in explosive mixtures moving at great speed, causing active combustion inside the lamp, heating of the lighter-case might determine the simultaneous explosion of several fulminate dabs, sufficient to ignite the explosive mixture ; but experiments made with Marsaut and Mueseler lamps in air and lighting-gas mixtures of the maximum explosibility, moving at a mean speed of 35$\frac{1}{2}$ feet (10·8 metres) per second, showed that, although the explosive mixture burnt intensely inside the lamps, which were highly heated, the fulminate was not ignited. It appears therefore that the addition of this lighting-arrangement to Mueseler and Marsaut lamps transformed for burning spirit does not impair their safety. J. W. P.

SUSSMANN ELECTRIC SAFETY-LAMP.*

Lampe Électrique de Mineur du Système Sussmann. By S. Hanappe. *Publications de la Société des Ingénieurs sortis de l'Ecole Provinciale d'Industrie et des Mines du Hainaut*, 1896-97, *série* 3, *vol. vi.*, *pages* 40-43.

The Sussmann electric lamp, combined with an accumulator, which has been tried at the Bracquegnies colliery, Belgium, afforded results which satisfy both the manager and the men. It consists of an accumulator with a consistent electrolyte, contained in a metal case, and an incandescent lamp enclosed in a special mounting above, the whole resembling an ordinary safety-lamp.

The accumulator is formed of prepared lead plates, covered with oxide of lead for the positive, and refined lead for the negative ; and each of the two compartments of an ebonite box, 5 inches by 2·5 inches by 2·5 inches, contains one negative and two negative plates, separated by strips of indiarubber and the consistent electrolyte, the two cells being connected up in multiple arc, so that the mean voltage is about 4 volts. The plates, their connexions and the electrolyte are covered by a thick layer of insulating material, extending over the terminals, and over two small tubes with ebonite plugs, small holes in the latter serving for the disengagement of the vapours and introduction of the acidulated liquid for keeping the electrolyte damp. The ebonite box has an outer case of sheet-iron, while its cover contains the connecting wires, with elastic contacts, which connect the terminals with the filament of the incandescent lamp. Between the cover of the accumulator, which forms the base of the lamp's mounting, and the iron cap provided with the ordinary carrying ring, is a thick glass cylinder for protecting the electric glow-lamp, the joints being made good by indiarubber washers.

The glow-lamp, which has a very short filament, is fitted with a reflector for concentrating the light on one side. With a luminous intensity from 2·5 to 5 times that of oil-fed safety-lamps—this comparison having been made with a perfectly clean oil lamp—the accumulator will maintain a light for 12 to 15 hours ; and about 3·7 horsepower is sufficient to charge 1,000 lamps at a time.

Although, as at present constructed, the Sussman lamp weighs 4·30 lbs. (1·95 kilogrammes), there is reason to believe that its weight may be reduced, while, weight for weight, its luminous intensity is from 1·5 to 3 times that of oil lamps. Finally, this lamp lights equally well in any position, and is not extinguished in a sharp air-current or by an explosion. J. W. P.

UNUSUAL ASSOCIATION OF MINERALS WITH ROCK-SALT.

Sur le Sel Gemme métamorphique de Salies du Salat. By A. Lacroix. *Bulletin de la Société Française de Minéralogie*, 1898, *vol. xxi.*, *pages* 29 *to* 30.

The intrusive ophites and cherzolites of the French Pyrenees determine, at their junction with the Mesozoic limestones, marls and grits, intense metamorphism giving rise to the production of a whole series of minerals, many of which were until recently considered to be exclusively associated with plutonic, and especially granitic, rocks.

Borings put down at Salies du Salat struck the rock-salt at depths of 670 and 815 feet respectively : the salt is of coarse structure ; grey, white, red, or violet in colour, and is mingled with a little anhydrite, gypsum and pyrites. At a depth of 850 feet, little crystalline nodules were found in the mass of the salt, consisting of such

* *Trans. Inst. M.E.*, vol. vi., page 264.

minerals as calcite, colourless or pale yellow phlogopite, rutile and tourmaline. These minerals are also dispersed singly in the salt: their form is indistinct, they show rounded faces, and they are not determinable by crystallographic methods.

Although no ophite was met with in the borings, that rock abounds in the near neighbourhood, and there is no doubt as to the connexion between the presence of the ophite and the occurrence of the above-mentioned minerals in the rock-salt. L. L. B.

SALT-MOUNTAIN OF EL UTAIA, ALGERIA.

Note sur la Montagne de Sel d'El-Outaïa. By Ch. Tardy. *Bulletin de la Société Géologique de France*, 1896, *série* 3, *vol. xxiv.*, *pages* 1075-1077.

This mountain dates from the end of Tertiary times, and is surrounded by a girdle of thermal springs. Amidst bare hills of variegated marls and serrated peaks of thinly-bedded, vertical bright red rocks, rises the great salt-hill—made up of concentric domes of gypsum in large crystals, marls [?], and rock-salt. The latter is almost pure white, but for a slight greenish tinge. The Arabs work it without proper tools, breaking up the salt by means of big pebbles. South-west of the salt-mountain are bluish-black plastic clays and an outcrop of a green, polished rock recalling the serpentines or ophites of the Lower Pyrenees. El Utaia is 1 mile distant from the railway-line to Biskra, on the verge of the great desert. L. L. B.

SALT-DEPOSITS OF LOUISIANA, U.S.A.

The Avery Island Salt-mine and the Joseph Jefferson Salt-deposit, Louisiana. By A. F. Lucas. *The Engineering and Mining Journal* (*New York*), 1896, *vol. lxii.*, *pages* 453-464, *with two illustrations.*

The Avery Island salt-mine was accidentally discovered in 1862, while sinking a well, and rock-salt was found at about 20 feet below the surface. Owing to the blockade, salt at that time was a luxury; therefore it was at once utilized by the Confederate Government and shipped by teams and rail where most needed in the Southern States. From 1879, systematic work has been carried on at Avery Island by the American Salt Company and later on by the New Iberia Salt Company of New York.

Numerous bore-holes, by diamond drills, were made by the New Iberia Company; and recently by Mr. Joseph Jefferson, the eminent actor, at his winter home at Orange Island. Owing to the great purity of the Avery Island deposit—from 97 to 99 per cent. of sodium chloride—the salt is mined, milled and marketted without any treatment whatever. The salt is loaded and hoisted in ordinary mining cars, dumped on top of the head-frame, passed through a crusher, sized through a series of screens for coarse grades, and the fine is milled through ordinary milling stones. The operation as a whole is very simple and produces from the coarsest capping salt to the finest edible table salt.

The Joseph Jefferson salt-deposit was discovered in the early summer of 1895, at a depth of 235 feet, whilst boring for artesian water. Eight holes were subsequently bored, by advice of the author, from 600 feet to 2,500 feet apart and from 150 feet to 2,100 feet deep. A finer or purer salt-deposit has not yet been found in North America, and it is believed that it will certainly match in time the greatest and purest deposit of the world at Wieliczka, Poland.

The borings made by the drill varied from 90 to 400 feet in depth before salt was reached. In one hole, where salt was found at a depth of 235 feet, the diamond drilling was continued to a depth of 2,100 feet without piercing the huge deposit of salt. This proves that there is, at least, a thickness of 1,865 feet of pure rock-salt. For every practicable purpose, the writer says, Mr. Jefferson has proved salt enough to supply the United States for hundreds of years.

J. W.

PLANOFERRITE AND CHILI SALTPETRE.

Mineralogische Notizen aus Atacama. By L. Darapsky. *Zeitschrift für Krystallographie und Mineralogie*, 1898, xxx. 205-216. With 1 figure in the text.

1.—A natural sulphate of iron, called by the author planoferrite, was found in the Lautaro copper-mine, close to the Morro Moreno, on the peninsula opposite Antofagasta. It occurs in druses in copiapite, in amber-yellow to dark brown crystals with tabular rhombic or hexagonal faces. These are mostly dull, corroded, and speckled with whitish saline particles, but sometimes they glisten with their true lustre. The mineral is brittle, and shows very perfect cleavage. Its hardness is that of calcspar, and the streak chrome-yellow. Dissolved in water it precipitates a brown-yellow basic iron salt. Chemical analyses show that planoferrite is the most basic and the most highly hydrated iron sulphate yet discovered, its composition being as follows:—

	Per Cent.
Iron oxide	31·20
Sulphuric acid	15·57
Water	51·82
Insoluble residue	1·41

Corresponding to the formula: Fe_2O_3, SO_3, $15H_2O$.

The author discusses the origin of this and the minerals which most nearly approach it, such as fibroferrite, raimondite, etc., and traces them to the disintegrating and decomposing action of waters percolating through [illegible] copiapite.

2.—In the mining property of the Oficina Sud Americana, Taltal, near the Guanaco gold-mine, the nitrate-deposits are extremely irregular, being constantly interrupted by barren rock, saline and ferruginous clays, or conglomerates. Sometimes, the payable nitrate is found within 1 or 2 feet of the surface of the ground, at others it lies many feet below. Rock-salt is here a less frequent associate of the nitrate than lime and magnesia. The author describes a mass 4 feet in thickness, made up of a complex of glauberite, blödite, thenardite and saltpetre (nitrate). Samples of the last-named yielded the following analyses:—

	(1)	(2)
Calcium sulphate, $CaSO_4$	4·4	23·3
Sodium sulphate, Na_2SO_4	6·0	34·1
Magnesium sulphate, $MgSO_4$	1·2	8·3
Sodium nitrate, $NaNO_3$	38·6	21·2
Sodium chloride, NaCl	9·5	5·4
Gangue	40·3	4·4
Water	0·7	5·0

L. L. B.

ADJUSTABLE SHOOT FOR LOADING COAL.

Note sur un Trémie pour le Chargement des Charbons. By A. Godeaux. *Publications de la Société des Ingénieurs sortis de l'Ecole Provinciale d'Industrie et des Mines du Hainaut*, 1896-97, *vol. vi., pages* 386-388, *with* 1 *plate.*

The Société des Charbonnages de Bascoup has endeavoured to diminish loss of coal by taking all possible precautions for minimizing the causes of breakage; and it has modified the loading shoots so as to lessen the fall of the pieces and distribute them uniformly. The coal was formerly loaded by telescopic shoots with movable ends, which worked perfectly well, but did not evenly distribute the coal over the whole surface of a waggon, so that hand-work was required.

The new shoot is of fixed length and no longer telescopic, its bottom being pierced with narrow longitudinal slots, alternating with one another so as to form a grating; and any dust that may be carried along by the pieces or formed after screening is thus separated before reaching the waggon, falling on to the quay-wall, whence it may be shovelled up and loaded into trams. The shoot terminates in a cylindrical portion, riveted at such an angle as to come about horizontal; and round the bottom of this latter portion turns a light spout set at about the same angle as the main portion of the shoot, and capable of making a complete revolution. The spout is telescopic, with a movable (pivoted) end, the overhang being counterbalanced, while the spout can be fixed immovably with respect to the shoot when required. The whole arrangement of shoot and spout is capable of moving through a slight vertical arc upon an axle carried by a girder; and it is also counterbalanced by a chain and counterweight, so that it can readily be deflected to any required angle by means of a hand-winch. The shoot may also be turned radially in a horizontal plane to a certain extent, about equal to half a waggon's length; and a combination of these three motions—deflection in a vertical plane, deviation in a horizontal plane and turning of the spout horizontally round the outer end of the shoot—permits of delivering the coal without fall or breakage at any point of a waggon, and as easily in the corners as in the middle.

J. W. P.

ELIMINATION OF FINE DUST FROM COAL TO BE WASHED.

Note sur la Séparation des Charbons pulvérulents par l'Action d'un Courant d'Air. By — Parent. *Annales des Mines*, 1897, *series* 9, *vol. xi., pages* 123-128, *with* 1 *plate.*

The presence of fine dust renders difficult the washing of coal; classification of the grains cannot be made so easily; the loss in washing increases; and the washed grains, charged with dust, take up so much water that they must be dried before being made into briquette-fuel. All managers of washing-floors therefore endeavour to separate the dust before washing; and they generally succeed, to a certain extent, by the aid of wire-gauze sieves. In Germany, the small coal to be washed is subjected to the action of an air-current for drawing off the dust, as at the Rheinpreussen and Zollverein collieries; and the Anzin Company, in France, has for the last few years used apparatus depending on the same principle.

A trial apparatus, erected at the washing-floor of the Saint-Louis pit of the Anzin collieries, consists essentially of a centrifugal fan, delivering a sufficient volume of air with a water-gauge of $2\frac{3}{8}$ to $2\frac{3}{4}$ inches (6 to 7 centimetres); an air-pipe terminating in a swan-neck leading upwards to a dust-chamber, which is fitted with the necessary diaphragms and distributors; and a series of bins for storing the classified products. The small coal is delivered by a distributor

situated immediately over the nozzle of the air-pipe, the blast carrying the lighter particles forward, between a couple of diaphragms, into the chamber: and the heavier pieces fall, down the swan-neck, on to the valve. The dust is classified by gravitation and collected automatically in a series of boxes in the chamber, the finest particles of all impinging against the front wall and dropping down into a distributor below; or, a still more minute classification may be effected by opening a door in the wall and allowing the blast, with particles in suspension, to escape.

The air-classifier at the Lagrange pit, depending upon the same principle as the preceding, but simplified, consists essentially of a distributor and a spreading-screw making 70 revolutions per minute, and through which may be passed 12 tons per hour of a non-bituminous dust up to 0·20 inch (5 millimetres). This dust, falling in a sheet, is received on a very short surface set at an angle of 45 degrees, where it is subjected to the action of a thin but wide horizontal air-blast having a speed of 85 feet (26 metres) per second. Under this action, the light particles are carried over the upper edge of a shutter, the inclination of which may be varied; and the heavy grains which have escaped the action of the air-current fall down the inclined plane into a stream of water, which conveys them to the water-classifier.

In normal working, this apparatus treats nearly 12 tons of small coal per hour, and eliminates from it about 17 cwts. (840 kilogrammes) of fine dry dust, while consuming 33,050 cubic feet (936 cubic metres) of air with a water-gauge of $1\frac{3}{4}$ inches (44 millimetres). In 1893, the Lagrange fine-coal up to 0·20 inch (5 millimetres), containing 16·81 per cent. of ash, when separated by washing alone gave 78·34 per cent. of washed coal (ash 9·52 per cent.); 9·66 per cent. of tailings (10 per cent. of ash), and 12 per cent. of slates (70 per cent. of ash), the loss necessary to gain 7·29 units of ash being 21·66 per cent. of the coal, or a coefficient of loss in washing equal to (21·66 ÷ 7·29 =) 2·97 per unit of ash gained. When the air-blast is used on fine coal up to 0·32 inch (8 millimetres) in diameter and containing 17 per cent. of ash, 8 per cent. of dry dust (16 per cent. of ash) is obtained, and the residue supplies 76·74 per cent. of washed coal (6 per cent. of ash), 7·70 per cent. of tailings (10 per cent. of ash), and 15·56 per cent. of slate (72·70 per cent. of ash), the coefficient of loss in washing being thereby reduced to (7·70 ÷ 15·56 ÷ 10·81 =) 2·15 per unit, and the unsaleable tailings lessened by one-fourth.

C. S. AND J. W. P.

SILVER-TIN ORE-DEPOSITS OF BOLIVIA.

Die Silber-Zinnerzlagerstätten Bolivias. *By the late* A. W. STELZNER. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 1897, *vol. xlix., pages* 51-142, *and* 1 *map.*

Messrs. Elie de Beaumont and Daubrée, among other geologists, gave expression to the view that in all localities stanniferous-veins occurred, not only under the same geological conditions, but were identical down to the smallest detail in their mineralogical characteristics. This rule may hold good for regions so widely separated as the Erzgebirge and Tasmania, the Harz and Colorado, but it is not universally applicable, and the author proceeds to show that the Bolivian deposits form an important exception.

Stanniferous-veins and stream-tin deposits have been worked at intervals in Bolivia since the days of the Incas, and at the present time tin ranks next in importance to silver among the metals produced in that country. Production and export are much facilitated by the new railways which place the mines in communication, on the one hand, with the Pacific coast, and on the other, with the Argentine slope of the Andes.

The author describes, in considerable detail, the orography and geology of the high central plateau (Alta Planicia Central) of Bolivia. It is bounded on the east by the Cordillera Real, consisting mainly of highly contorted Devonian and Silurian clay-slates, grauwackés, and sandstones. The high tableland is mantled over by loess, through which, here and there, rise, like rocky islets, outliers of the underlying Permian and Permo-Carboniferous strata. On the west, the coastal Cordillera appears to consist chiefly of Jurassic rocks interbedded with contemporaneous porphyry-tuffs. The formations enumerated above are broken through by "granites" of Palæozoic age, "porphyries," diorites, trachytes and trap-dykes, and to these must be added the *ejectamenta* (lavas, etc.) from the still active volcanoes of the coastal Cordillera. It is among the dacites and rhyolites of Hillabaya, Potosì and Oruro, and among the Upper Cretaceous or Tertiary volcanic rocks (quartz-trachytes, mica-andesites, etc.) of the Cordillera Real that the argentiferous and stanniferous-veins mostly occur.

Three groups of metalliferous veins are recognized in Bolivia, with a general north-north-west to south-south-east strike, following the lines of fissure, which are intimately connected with the various eruptive formations. The first group, associated with the Lower Devonian "granite" of the Illampu-Illimani chain, is variously mineralized with gold, silver, mispickel, bismuth, nickel, zinc blende, galena and pyrites. In the Rio Tipuani are gold placer-deposits derived from the auriferous-veins of this group.

The second group is associated with the post-Jurassic and pre-Cretaceous diorites which crop out on the western slope of the coastal Cordillera. The veins here are chiefly characterized by combinations of sulphur and arsenic, with silver and copper. Here and there lead and zinc-ores and auriferous pyrites come in.

The third group, recognized only in recent days, lies geographically between the two others, and its economic importance resides, firstly, in its silver-ores; secondly, in its tin-ores; and, thirdly, in its bismuth-ores.

The cupriferous deposits of Corocora and Chacarillo belong to none of these three groups. It is with the third group that our author specially concerns himself.

The silver-tin-bismuth deposits occupy, in the high central tableland of Bolivia, a belt some 150 miles broad, stretching over nearly 6 degrees of latitude from 15 degrees 10 minutes south latitude on the northern shores of Lake Titicaca (well within the Peruvian province of Huancané) to 21 degrees south latitude in the Bolivian province of Chichas. The author has carefully examined the evidence for the reported occurrence of rich tin-ore deposits in Ecuador, Chile, Argentina, Brazil, etc., but finds that where it is not imaginary or grossly exaggerated it is based on specimens actually brought from the Bolivian plateau. He then gives a summary of the mines worked on this plateau, and from his description the following particulars are extracted. Going along the mining-belt from north to south, we come first to Moho (Huancané), apparently the only mine within the Peruvian boundary whence tin-ore is got. The ore is a plumbo-stannite, associated with zinc-blende and quartz. The mines of Carabuco are not now worked; cupriferous tin and silver were got here by the Incas, and after them by the Spaniards. Among the spurs of the great mountain of Huayna Potosì lies the Milluni mine. Here the stanniferous lode attains a maximum thickness of 39 inches. The vein-stuff is tinstone, antimony-nickel glance (ullmannite), and quartz.

In the valleys, which run down eastward from the snowcapped peaks of the Illampu-Illimani chain, are many gold-placers with which are associated pebbles of

tinstone. Going southward still, at Coliquiri we find mines, whose tin-ores being now exhausted, work in the deeper levels lead and silver-ores. San Felipe de Oruro owed its rise to the discovery in 1568 of rich silver lodes. Two and a half centuries of prosperity were followed by a long period of depression, but there has been of late years a great revival in the mining industry of the neighbourhood. Four large mines are at work, and there is direct railway-communication with the Chilian coast. The lodes run partly through clay-slates and partly through dacites: near the surface they pitch 45 degrees, and deeper down 85 degrees to north-north-west, with a general south-south-west to north-north-east strike. The ores got here are pyrites, silver, tinstone, galena, etc., and the average daily productions is 28 tons. The percentage of silver averages 0·31 or 110 ounces per ton. Rich ores, with more than 400 ounces per ton are exported in the raw state. Iron pyrites in masses 2 to 6 feet thick contains between 5 and 20 per cent. of tin, and this is usually so intimately associated with the silver-ores that it cannot be separated from them by hand-picking. The workings have been carried down to a depth of 1,140 feet below bank. The Morococala and Huanuni tin-mines have also long been worked, and are still very rich in the deep levels.

At Aullagas are rich silver-lodes in dacite. In one year (1883), the silver production from this mine reached 3,200,000 ounces. Recently there has been a revival of the silver and tin-mining industry in the historic district of Potosì. Some of the lodes run through quartz-trachyte, others through the slate which forms the base of the Cerro de Potosì: they are said to be more than 60 in number. The ores are antimony fahlore (with 2·2 per cent. of silver), iron and copper pyrites, blende, galena, arsenical and stanniferous pyrites, tinstone, etc. The author discusses their mode of formation, etc., and concludes that the tin-ores are of the same age and origin as all the accompanying sulphides. Argentiferous lodes cutting through trachyte were worked in the Porco district for many centuries, and the Misericordia mine has lately been re-opened to work a silver and tin lode from 2 to 8 feet thick. Down to a level of 195 feet below the surface, the average silver-content of the ore is 0·06 per cent., and the tin 30 per cent. Lower down, the lode becomes all but barren in tin, but much richer in silver, the percentage of the last-named varying from 0·15 to 0·50. At the high level, the gangue is quartz, hæmatite and clay-galls, at the deep level quartz alone. Near by is the Pic de Gallo silver-mine, where the lode runs at right angles to that worked at the Misericordia.

At Pulacayo, another locality whose mining industry has passed through many vicissitudes, a company are working a mine by an adit driven into a hill of red conglomerates and marls (probably Permian), into which is intruded a porphyritic dacite. The mine communicates by a narrow-gauge railway with the harbour of Antofagasta, some 400 miles distant. This should enable even the poorer ores (which still go to the waste heap) to be treated for the extraction of their 0·18 to 0·25 per cent. of silver. Some of the ores are treated at Huanchaca, 6 miles north of Pulacayo, and the remainder is shipped direct to Europe. The vein-stuff is made up of zinc-blende, fahlores, galena, and copper pyrites, a little bismuth, and tin-ore. The percentage of silver averages 0·4 to 0·5, but in places it is as high as 10, 12, and even 13. The Tasna and Chorolque mines are especially rich in bismuth; and at Cotagaita, tinstone associated with silver, lead, copper, and iron-ores is worked, and also stream-tin.

Many other mines are enumerated and described, which are not now worked; and the author, recapitulating the evidence regarding the lodes of the Bolivian high plateau, points out that not only are they peculiar in the association of stan-

niferous ores with wolfram and the sulphides and the sulpho-salts of silver, copper, lead, zinc, bismuth and antimony, with a gangue of quartz, baryta and spathose carbonates ; but with the presence of the foregoing minerals must be coupled the absence of a whole series of minerals which, in all other stanniferous regions—in Europe, Asia, Australia, and North America are the never-failing associates of tin-ore, as for example, tourmaline, fluorspar, and topaz.' In consideration of these and other facts, the author proposes to classify the Bolivian tin-lodes entirely apart as the Potosi type. L. L. B.

DEEPENING A WINDING-SHAFT BY THE AID OF ITS AIR-SHAFT.

Charbonnage de Grande Machine à Feu de Dour: Approfondissement du Puits Frédéric. By J. DE JAER. *Annales des Mines de Belgique*, 1898, *vol. iii., page* 133-135, *with one illustration.*

The shaft was deepened 102 feet (31 metres) in six months, without interfering with the winding of coal, and in the following manner :—A certain thickness of rock was left provisionally between the bottom of the existing shaft and the top of its continuation ; and a drift was driven from the air-shaft to a point a little below this mass. At the floor-level of the drift, the air-shaft, and also the winding-shaft after the deepening had begun, was closed by a strong floor, that of the winding-shaft, however, having an opening, provided with keps, for the passage of a small cage holding a single tub. The air-shaft was fitted with guides down to the communication-drift, as also was the winding-shaft as the work of deepening proceeded. A small cage, similar to that for the winding-shaft, was let down the air-shaft by a steam capstan on the surface, taking with it an empty tub at each lift ; and these tubs were ranged in a set on one of the tracks laid in the communication-drift. When six or eight empty tubs had been let down, they were pushed along the drift to the winding-shaft. The winding-rope was then disconnected from the cage in the air-shaft, carried along the drift (being supported by guide-pulleys) passed over a pulley in an upward excavation of the sinking-shaft, and hooked on to its cage, an operation that only required a few minutes. The empty tubs were then, one by one, let down the sinking-shaft, and drawn up filled with the material excavated ; and, when six or eight were assembled in the drift, they were braked down to the air-shaft and drawn up the latter, one by one, the rope being disconnected from the cage in the sinking-shaft and connected with that in the air-shaft. The excavated rock drawn up was either used as gob-material for the workings at a higher level or taken up to the surface. One man sufficed for handling the tubs in the communication-drift, receiving the signals of the sinkers and transmitting them to the engineman of the capstan.

The advantages of this method are :—(1) Saving of labour ; (2) rapid advance ; and (3) greater safety than in the direct deepening of a shaft. Indeed, when the cage was not being let down or drawn up in the sinking-shaft, it rested upon the keps, and thus closed the shaft better than would the trap-doors or other contrivances generally used ; and the same was the case while the tubs were being loaded on to or drawn off from the cage, while the work was easier and less dangerous than that with kibbles. Lastly, as the cage was guided in a special compartment, the sinkers had only to keep outside it, while the cage was running in the shaft, to be out of danger in the event of the rope breaking. J. W. P.

MODIFICATION OF THE KIND-CHAUDRON METHOD OF SINKING.

Charbonnages des Produits: Siège No. 27-28, Avaleresse de Jemappes. By E. Orman. *Annales des Mines de Belgique*, 1897, *vol. ii., page* 705.

The cast-iron tubbing rings for No. 28 shaft, of 14 feet 1 inch (4·3 metres) inside diameter and 4 feet 11 inches (1·5 metres) high, were let down to the hard impermeable rock, met with at the depth of 544 feet (165·7 metres), or 21 feet (6·4 metres) above the Coal-measures. The management of the colliery, instead of using the moss stuffing-box of the Kind-Chaudron method, conceived the idea of bolting to the bottom of the tubbing an indiarubber ring, 2 inches (5 centimetres) thick, and having at its lower edge 48 oblique teeth, 2 inches (5 centimetres) deep, the object of which was to permit, by giving a rotary movement on its axis to the tubbing before it bedded definitely on the rock, of sweeping the ledge clear of *débris*, which fell into the central hole, then 563 feet (172·85 metres) deep.

Another departure from the Kind-Chaudron method was made by dispensing with the counterbalancing column of water inside the tubbing, the hole in the false-bottom being simply closed by bolting over it a cover-plate, so that the tubbing became a hollow cylinder 514 feet (156·75 metres) high, except that the bottom was about 5 feet (1·5 metres) above the lower edge. This tubbing was let down by means of six suspension-rods as regards the 8 lower rings, and by flotation for the 97 others, water being poured on to the false-bottom as required, until at last the whole of the inside was filled with water, for pressing the tubbing as closely as possible on to the rock ledge. The annular space of about 10 inches (25 centimetres) that remained between the tubbing and the inside of the shaft was then filled in with concrete, after which the water was drawn out of the tubbing by buckets. So soon as the false-bottom was laid bare, it was ascertained by experimental observations, made by means of tap-bolts in the false-bottom, that the quantity of water to be pumped would be about 110,000 gallons (500 cubic metres) per 24 hours for permitting the deepening of the shaft, under the bottom of the tubbing, after the removal of the false-bottom. Accordingly, two steam pumps were set to work ; and the shaft was further sunk 6½ feet (1·95 metres) in the impermeable rock, for wedging thereon two curbs, each about 10 inches (25 centimetres) high, one above the other. Over the curbs were laid, in segments, two supplementary tubbing rings, each 2 feet 4 inches (70 centimetres) high, behind which concrete was filled in as well as possible ; and the space still remaining was made good by horizontal wedges. Inasmuch as it was found that water still flowed from fissures under the wedged curb, this water was received in a tank, from which the pumps drew, in order that the curb might be freed from strain while the sinking was continued by the method of pumping out the water. J. W. P.

SINKING SHAFTS, WITH THE AID OF FREEZING, THROUGH QUICKSAND AT GREAT DEPTH.

Note sur le Fonçage des Puits à grande Profondeur par le Procédé Poetsch. By — Saclier. *Bulletin de la Société de l'Industrie Minérale*, 1897, *série* 3, *vol. xi., pages* 647-654, *with* 2 *illustrations in text.*

The bore-holes for receiving the refrigerating pipes should be spaced equally over a circle of 2 to 3 feet larger radius than that within which the sinking is to be effected. The inside of the future shaft, especially if it has to be sunk to a great depth, must not be frozen, because the simultaneous presence of two sources of cold - one round the circumference and one in the middle -would cause the for-

mation of two distinct ice masses; and, as the specific heats of the various rocks passed through are essentially variable, the uniting of these two ice masses would not be effected simultaneously. The consequence would be that aquiferous zones imprisoned in the ice would, on becoming frozen, determine by their expansion reactions upon the refrigerating pipes which would flatten or break them.

Called upon to study an application of the Poetsch process to sinking a shaft in the Cretaceous rocks that overlie the Coal-measures on the northern slope of the Mons basin, the author perceived the great difficulty that might arise through a deep bed of quicksand being overlain by an impermeable stratum, and devised means for surmounting it. The rocks in question, which may attain a thickness of 1,300 feet (400 metres), consist at their base of very aquiferous Greensand, directly overlying the Coal-measures.

A bore-hole put down to about 328 feet (100 metres) in the Coal-measures, which were struck at 744 feet (226·7 metres) deep, showed that sinking a shaft on its site with the aid of congelation would require special precautions, owing to the large mass of water in the Greensand, separated from the surface by 168 feet (51·2 metres) of plastic clay and chalk. In fact, when a complete ice-tower is formed through the action of the freezing-pipes, put down round the circumference of the shaft to be sunk, there will be set up, owing to the expansion of the solidified water, an over-pressure which, increasing with the advance of the congelation, might become enormous. The cylindrical mass, completely shut in by the ice tower gradually advancing inwards, by the impermeable clay above and the Coal-measures below, would be subjected to excessive pressure, which would increase until it might put out of shape the weakest portions of the enclosing walls. It could not force upwards the impermeable clay; but it would flatten the freezing pipes, thus rendering it impossible to continue the congelation, in which case the whole work would be lost.

For overcoming this difficulty, the author advises that a bore-hole should be put down to the Coal-measures in the centre of each shaft to be sunk; and this communication with the surface would naturally prevent any abnormal pressure inside the shaft, since the water, under the influence of the expansion of the ice towers and over the whole height frozen, could rise and flow out on the surface. For effecting this, however, measures must be taken for preventing the bore-hole itself from being reached, and stopped up, by ice at the level of the rocks which are better conductors of cold and having slighter specific heats, which might well occur with the plastic clays. These beds, perfectly free from water, have a higher coefficient of conductibility than the other strata passed through, which are impregnated with water; and their specific heat is not greater than 0·2. The bore-hole might at this point very easily become frozen up before the complete removal of the water contained in the cylindrical mass; but this might be prevented by warming the bore-hole by a pipe, fitted with a cock and leading steam or hot water down to the bottom of the plastic clays, and also carrying up an equilibrium pipe to such a height above the surface as would counterbalance the over-pressure.

At the beginning of the congelation, the cock might remain closed without danger of the bore-hole being frozen, owing to the immense number of heat units to be abstracted from the rocks before the ice-tower can be formed; but, directly this takes place, the fact would be made known by the water under pressure inside the cylindrical mass issuing from the equilibrium pipe. This flow would afford a certainty that the ice-tower was formed; and it would only be then that the steam or hot water should be admitted into the bore-hole by opening the cock from time to time. J. W. P.

AN AIR-SHAFT WIDENED AND DEEPENED WITHOUT HINDRANCE TO WORKING.

Elargissement et Creusement du Puits d'Air de Leval-Trahegnies, Hainaut. By Camille Richir. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut,* 1896-97, *series* 3, *vol. vi., pages* 409-414, *and* 1 *plate.*

The work of widening and deepening the air-shaft was to be effected without interference with the working; and all necessary measures were to be taken to effect the maximum advance in case of need, while the new shaft was to be lined with masonry. The original shaft had been sunk in a straight line to the depth of 686 feet (209 metres), with a diameter inside the lining of 7 feet 4 inches (2·25 metres), below which depth a series of small shafts, not in the same line, communicated with one another and with the main shaft. In order not to interrupt the working, a small ventilating shaft was put down 66 feet (20 metres) on one side of the main air-shaft, which was hermetically sealed off just above the crown of the drift connecting it with the small ventilating-shaft, while the latter was also closed by a strong floor at the ground level.

The widening of the main air-shaft was then effected, from the mouth down to the tight stopping, by ordinary methods, the quantity of water encountered having been insignificant; and its masonry lining was made 18½ inches (47 centimetres) thick at its seating on the rock-ledge, and 3 feet 3⅜ inches (1 metre) thick at the ground level, the object of this taper being to permit the lining to jam tightly against the rock. The lining was carried up 26 feet (8 metres) above the ground level; and on the tower thus formed was mounted all the gear necessary for widening the shaft. An air-lock was constructed at the ground level, and the top of the tower was covered in by a floor as tightly as possible, so that communication was restored between this portion and the remainder of the shaft.

An open-work platform, hung from two winches on the floor at the top of the tower, served as a standing place for the miners, while preventing their fall down the shaft; and also for permitting the passage of air, while only allowing small pieces of rock to pass. The pieces falling through the open-work platform were received, at the bottom of the shaft, on stout shelves, opposite to and overlapping one another, and thence, directed by a partition, to a rise drift put up from the landing. This rise, which also served to store all the material excavated in a day, was provided with a hopper for loading the tubs which took it up to the surface by the winding-shaft.

When the miners got down with the widening out to the depth of a length or section of walling, a cradle for the masons was let down to the rock-ledge, being suspended by four steel wire-ropes. While the inside of the shaft is 13 feet 5 inches (4·1 metres) in diameter, that of the platform is 13 feet (4 metres); and the latter has in the middle a circular opening, protected by plates—at the top constituting a fender and below for guiding the kibbles—because it is through this opening that the excavated rock is raised. When the masons had built up the walling to the height of about 5 feet above their platform, it was drawn up to the desired height in 5 minutes at the outside, during which time the men remained standing on the top of the walling.

This "flying cradle," as it was called, affords the great advantage of saving time in drawing up; it does away with the necessity of leaving mortise holes in the walling, which are so unfavourable to its strength; and it permits the simultaneous sinking and walling of a shaft.

When the walling had been built up about 15 feet above the rock-ledge, the widening out of the shaft was resumed, the miners' cradle descending and that of the masons rising.

Below the level of 686 feet (209 metres), the shaft had to be excavated over its whole sectional area, because the upcast shaft did not extend lower in a direct line.

With this method a shaft may be sunk and walled at the rate of 6½ feet (2 metres) in the 24 hours under the conditions named above, or at the rate of 5 feet (1·5 metres) in virgin rock, and the cost can readily be estimated on the basis named above, which, the author asserts, may always be obtained. J. W. P.

STUDY OF MINE ACCIDENT STATISTICS, GERMANY.

Étude sur la Statistique des Accidents dans les Mines Allemandes. *By* MAURICE BELLOM. *Annales des Mines*, 1898, series 9, *vol. xiii., pages* 5-44, *with graphic diagrams.*

The General Mining Corporation, instituted by the law of 1884, as to assurance against accidents, recognized from the first the utility of complete and rational statistics, both as regards the distribution of the financial charges and the prevention of accident; but it was only after sufficiently long experience that the results shown by the statistics were considered instructive, and that the managing committee decided upon their compilation into the *Statistik der Knappschafts-Berufsgenossenschaft für das Deutsche Reich*, extending over the period from October 1st, 1885, to January 1st, 1895. The statistics thus bore upon 9¼ years, and comprised more than thirty thousand (31,679) accidents, more than three thousand (3,004) works (*exploitations*), more than three millions and a half (3,623,175) persons insured, and more than three milliards marks £152,208,552 9s 2d. (3,044,171,049 marks 16 pfenniges).

The data were furnished by the statistical cards prepared for each accident; and the marshalling of these data gave rise to the compilation of more than fifty (52) tables, a geographical map and four plates of diagrams. While some portions of these statistics have a purely national interest; others, devoted to the classification of the figures, according to the nature of the work, furnish information useful for all countries endowed with similar industries; and the author who confines himself to this second category, also divides the subject under the heads of technical and financial statistics.

The various works consist of coal-mines, lignite-mines, metalliferous-mines, salt-mines, and other mineral workings; and the technical statistics give figures from which percentages may be deduced as to the age, place, epoch, consequences, circumstances and causes of the accident. After dealing with the financial statistics generally, and under the heads of the various classes of mines, the author deduces from the accident statistics that, both as regards the prevention of, and compensation for accidents, there is great interest in compiling statistics special to given branches of industry, for a sufficiently long period, side by side with general statistics relating to the whole industrial enterprise of a country.

J. W. P.

SUBSIDENCES AT EISLEBEN IN THE MANSFELD MINING DISTRICT.

De la Formation des Cavernes a propos des Effondrements d'Eisleben. By Otto Lang. *Bulletin de la Société Belge de Géologie*, 1898, *vol. xi*, *pages* 190-220, *with* 1 *figure in the text, and* 2 *plates*.

The author discusses, in the first place, the various theories of cavern-formation, rebutting especially Prof. Flamache's contention that caverns are entirely the result of mechanical erosion. It is noticeable that large caves exist almost exclusively in such rocks as are chemically susceptible of attack by water and aqueous solutions of carbonic acid; and that the cavities in other rocks, due to broad fissures or tectonic disturbances, are of comparatively small dimensions. He then points out that those caverns which affect a chimney-like form really owe their vertical extension to successive fallings-in of roof and walls, and such caverns he proposes to classify apart from those due to chemical erosion the former he terms "chimneys," the latter "shafts" or "pits." Chemical erosion, slow as its work of cavern-making may be, has, however, far-reaching effects. Disturbances are ultimately set up in the strata over a wide area, and the damage inflicted on various forms of property, industrial and others, is of great moment.

The example of Eisleben, a town of 23,000 inhabitants, is sufficiently striking. Walls are cracked and out of the perpendicular, doors and windows are kept in position by iron ties, and whole rows of houses have been abandoned as unsafe. This state of things is due to a series of earth-shocks which began in the autumn of 1892, and continued with increasing frequency from December, 1893, to January, 1896. The ground sank in several places, and great fissures were opened in it. Everyone was agreed that this was not a case of ordinary earthquake, and that these alarming and destructive subsidences were assignable to some cause other than mountain-building thrusts or volcanic phenomena.

The greater part of the town is built on diluvial gravels, overlying lacustrine clays and sands, altogether about 33 feet thick, beneath which are the Lower Bunter rocks (Trias). The last-named are argillaceous in character, and such fissures as take place in them are quickly closed up by pressure, remaining impermeable to water. Below the 650 feet of Lower Bunter is the Zechstein, more than half made up of sulphate-of-lime rocks (anhydrite, gypsum). In this formation are chimney-shaped caverns occurring in groups, or strings as it were, along the bedding-planes, and the falling-in of some of these caverns would possibly disturb the overlying rocks. This of itself might be sufficient to account for the surface-subsidence; but it must be borne in mind that, to effect so much at Eisleben, the caverns would have to be at least 400 feet high—taking into account the mass of the Lower Bunter. Moreover, the area of the observed shocks, although small for an ordinary earthquake, is enormously greater than any area previously known to have been affected by the caving-in of gypsum caverns.

Mr. Leuschner, the manager of the Mansfeld copper-mines, maintained that the damage was due to waterlogging of the superficial deposits and consequent landslips, but this explanation was disproved: the origin of the shocks lay deeper down. Public opinion pointed to the underground workings of the Mansfeld Copper Company as the determining cause; and indeed, in the first instance, the company, as the result of an arbitration-award, paid over £25,000 as compensation for damage to buildings, etc., declaring, however, that this implied no acceptance in principle of responsibility, and disclaiming the creation of any precedent.

It may be pointed out that in this district, below the Zechstein are the dark, bituminous, marly shales, charged with copper sulphide and known as *Kupfer-*

schiefer. They rest almost directly on the great conglomerates and grits of the Rothliegende; and as the strata occupy a basin, open to the south-west, it often happens, near the edges of the basin, that the Zechstein is denuded away, and the Rothliegende comes into direct contact with the Bunter—this is, of importance in connexion with the percolation of surface-waters. The thickness of the whole of the metalliferous shales varies between 12 and 20 inches, yet from 5 to 9 distinct layers are recognized in them, and the miners have to work them in a recumbent position. There are several faults of considerable magnitude cutting across this basin, the chief of which in the Eisleben district is the Flötzgraben fault: this, in the Martin pit, is seen to have a throw of 100 feet.

The government inspector of mines, in his summary of the facts, recalled the continued diminution in the selling prices of silver and copper which had led the Mansfeld Company to extend more and more the area of production, so as to obtain the same yearly turnover. Thus their galleries were driven farther and farther into the basin, right underneath the town of Eisleben. His view was that by this means the subterranean waters ultimately found their way to the rock-salt associated with the anhydrite, and, carrying it off in solution left great cavities. Moreover, when the Kupferschiefer was exhausted in a portion of the workings, the miners were not especially concerned to pack carefully with dry stone as they went along; the unsupported roof, therefore, split and broke down. But the Mansfeld engineers appealed to the absence of water in connexion with the faults, to the fact also that the rock-salt occurred in quantities so small that its removal could not disturb large masses of rock, and that the anhydrite was interbedded with it in thin layers.

The author's explanation of the true cause may be summarized as follows. The fissures are all parallel to one another along a north-west and south-east line. This uniformity of direction proves that the shocks to which they were due did not radiate from a particular centre, but were spread initially over a great number of points. Now, while the Middle and Upper Zechstein consist mainly of anhydrite with intercalations of gypsum and rock-salt, we find in the Lower Zechstein much porous dolomite and a sandy dolomitic marl. This also occurs between the anhydrite and Zechstein properly so-called, associated with black bituminous fœtid shales. The dolomite marl, locally known as *Asche*, is the great water-bearing rock of the district: evidently it is the residue of a porous dolomitic limestone, and it points to a slow process of dissolution of carbonate of lime by waters charged with carbonic acid. This process is still going on; it conditions broad but low cavities parallel to the bedding-planes, and according to the variable permeability of the strata lacunæ become superposed on lacunæ; and then, at long intervals, there is a breakdown, with results such as those described at Eisleben. The removal of rock-salt and anhydrite and the caverns in the gypsum are associated phenomena, but not the main cause, if we understand aright the author's contention. L. L. B.

SALE OF SICILIAN SULPHUR.

Note sur les Conditions de Vente des Soufres de Sicile. By L. A. *Annales des Mines*, 1898, *série* 9, *vol. xiii.*, *pages* 317-320.

The disastrous influences of low prices on the sulphur-industry of Sicily, great as it was in 1893, made itself still more acutely felt in the succeeding years, and at the commencement of 1896 prices stood at exactly half what they were in 1891. The amount of sulphur produced had not, however, varied much from its annual average of 400,000 tons.

An Anglo-Sicilian Company was then formed, much on the lines of the old Copper Syndicate, and, by arrangement with the sulphur-producers, bought up practically all their sulphur and resold it on the European market at a fixed scale of prices. This resulted in a great rise in the course of 1896, by which some of the Sicilian producers profited to stand aloof from the syndicate, while some who had joined it did not keep to the terms of the contract.

Another result of the rise in prices was a great development of production. Workings long abandoned were reopened; mines were enlarged; new plant was put down; and exploration work was undertaken, even in quite hopeless localities.

Exports in 1896 amounted to 412,500 metric tons, the chief shipping-ports being Porto Empedocle, Catania, and Licata. In December of that year, the average selling price per metric ton had reached £3 13s. 6d. (92 lire 52 centesimi).

The official statisticians of the Italian Department of Mines are afraid that the ultimate result will be over-production and an accumulation of unsaleable stock. L. L. B.

EXTRACTION OF SULPHUR.

Mineralurgia dello Solfo. By G. Aichino. *Rassegna Mineraria.* 1897, *vol. vi., pages* 65-68.

Sulphur occurs in Sicily in a calcareous more or less marly matrix, clay and gypsum being rarer. It is more or less regularly and abundantly distributed, and is often accompanied by bituminous matter. The difference between the specific gravity of sulphur and that of the accompanying minerals is too small to admit of any of the ordinary methods of dressing or concentration, hence it has to be separated by methods of fusion, distillation, or solution. The first-named method is now alone employed, and may be applied in any of the following processes:—

(1) Fusion by means of the heat developed by a combustion of a part of the sulphur itself.

(2) Fusion by heating with wood or coal.

(3) Fusion by means of superheated steam.

(4) Fusion by means of a hot saline solution, the boiling point of which is higher than the melting point of sulphur.

The last-named system, proposed in 1868, was tried in Sicily in 1883, a solution of calcium chloride being employed, but it has not come into use. Similarly the method of heating by means of the externally applied heat of wood or coal fires has not come into general use, because the results obtained by it were unsatisfactory. It is now only used on a very small scale in Sicily for treating rich mineral in a state of powder.

The first-named method is applied in various ways. The most general is by treatment in kilns (*calcarone*) of large dimension, which were introduced into Sicily about 1850, and replaced the smaller ones (calcarella) used up to that time. It consists of a circular or elliptical brickwork structure, the bottom of which slopes to the front at an angle of 10 to 15 degrees. The mineral is charged through a door about 4 feet high and 10 inches wide; the floor is covered with big lumps, and the rest of the charge is piled on so that the bigger pieces are at the centre and the smaller towards the circumference, forming a cone, the upper portion of which is covered with residues of a previous operation. After it has been charged, the door is built up and the pile is fired; the sulphur separating out trickles towards the front, and is either tapped off continuously or at intervals. The time

of an operation from the commencement of charging to the casting of the last cake of sulphur lasts from 1 to 3 months, according to the size of the kiln, which may contain from 8,830 to 88,300 cubic feet (250 to 2,500 cubic metres). Some have been made as large as 176,600 cubic feet (5,000 cubic metres), but they now rarely exceed 53,000 cubic feet (1,500 cubic metres), those of small and medium size being preferred. The conduct of the process is difficult and troublesome, and the objections are the loss of a certain amount of sulphur and the generation of considerable quantities of sulphur dioxide. The average consumption of sulphur is one-third of that present in the ore, and it may rise to 0·4. The loss is greater with poorer mineral, and in practice none containing less than 10 per cent. is treated. The treatment of a ton of mineral costs about 8½d. (0·90 lire).

The only important improvement on the calcarone is the Gill furnace, patented in 188), which has since then undergone various minor modifications. It consists of a pair of chambers connected together : these are usually circular in plan, and taper slightly upwards. Their upper portions communicate by means of a flue fitted with dampers, and their lower portions open into a low stack ; one chamber is full of the hot residues, whilst the other is being fired ; the air to maintain combustion enters at the bottom of the chamber filled with residues, ascends through it, and is thus heated on its passage to the chamber containing the ore that is being treated. After the fusion in the second chamber is finished, the communication is closed, the first chamber is emptied and recharged, and the direction of the air-current is then reversed. In more recent plants, the number of chambers has been increased up to six, but is generally four. The height of the chambers is generally equal to or a little greater than the diameter of the base ; their capacity is usually from 353 to 1,060 cubic feet (10 to 30 cubic metres), but has been made as much as 1,766 cubic feet (50 cubic metres) with good results. In each chamber of the double furnace from 45 to 90 fusions per year can be performed ; and in that of the quadruple furnace from 24 to 60. This furnace can treat mineral directly from the mine, and its output is greater than that obtained from the calcarone, the increase being at times up to 15 per cent., thus compensating for its greater first and working costs ; but, on the other hand, the sulphur produced is inferior.

Steam heating was first introduced some 25 years ago, and now about 10 per cent. of the sulphur produced in Sicily is extracted by this means. The heat is more readily controlled in this way, but the output is not always greater, because the residue retains a considerable amount—from 8 to 15 per cent. of its weight—of sulphur. With ores containing over 25 per cent. of sulphur, the extraction by means of steam has the advantage, and the product is superior ; moreover, the sulphur can be obtained within a few hours after the mineral has been got out of the mine without the long delay necessitated by the calcarone, whilst the process is independent of atmospheric influences, and does not foul the air with sulphur dioxide. The cost per ton is, however, higher than in the calcarone process.

Two types of apparatus are in use, one carried on trunnions and the other horizontal. The former consists of a cylinder of cast-iron or more often of wrought-iron, supported on trunnions so that it can be placed vertically or horizontally. One of the ends is permanently closed, and the other has a movable cover that can be securely bolted on. A perforated longitudinal partition divides the cylinder into two parts, the lower of which is much the smaller and intended to receive the molten sulphur. The mineral broken small is charged into the larger division, the cylinder being vertical ; it is then turned into a nearly horizontal position slightly inclined towards the tap hole, the cover is bolted on and steam at 3½ to 4 atmospheres is turned on. The residues are removed by inverting the cylinder. The

usual dimensions are 4 feet (1·2 metres) in diameter, and 13 to 15 feet (4 to 4·5 metres) in length ; the charge is 5 to 5·5 tons, and 7 charges can be treated in 24 hours.

The horizontal apparatus has but recently come into use ; the cylinder is fixed and inclined at a gentle slope 8 to 10 per cent. to the horizontal ; the mineral is introduced in little cars, usually 4, so shaped as to fill the cylinder as completely as possible. In a recent plant, the cylinders are 3½ feet (1·1 metres) in internal diameter, and 17 feet (5·15 metres) in length, and take a charge of 4·4 tons, 15 to 16 of which are treated in the 24 hours.

The following table shows the development of these various methods of sulphur extraction in Sicily :—

Year.	Percentage of Sulphur produced in		
	Calcaroni.	Regenerating Furnaces.	By Means of Steam.
1891	74·50	17·00	8·50
1892 ...	68·82	21·08	10·10
1893	67·00	25·00	8·00
1894	64·30	26·45	9·25
1895	56·30	31·00	12·70

H. L.

MAGNETIC ANOMALY IN RUSSIA.

Anomalie magnétique observée en Russie. By — Moureaux. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1896, *vol. cxxii., page* 1478.

The greatest magnetic anomaly hitherto encountered was observed, on June 12th and 13th, 1896, at Kotchetovka, 20 miles south-south-east of the town of Obojaune, where in an area of about 247 acres (1 square kilometre) the declension of the needle was found to vary between + 58 and — 43 degrees, the dip between 79 and 48 degrees, and the horizontal component between 0·166 and 0·589.

This last figure, checked by six other observations at neighbouring points, giving values varying from 0·48 to 0·58, is far greater than the maximum in the equatorial region, which does not attain to 0·40 ; and, as the dip at the point in question is not less than 48 degrees, the magnetic force must be enormous.

At Potrovskoje, 10 miles south of Kotchetovka, the declension was found to be 52 degrees 56 minutes, the horizontal component 0·09, and the dip 81 degrees 45 minutes ; and, wishing to know if this last figure was a maximum, the author went in the direction of the magnetic north, and found the maximum to be 82 degrees 13 minutes where the horizontal component was only 0·079. The same needle was used in all the observations ; and its deviations, which were only 7 degrees 22 minutes at Kotchetovka, attained 72 degrees 23 minutes at Potrovskoje.

J. W .P.

PREPARATION OF TUNGSTEN IN THE ELECTRIC FURNACE.

Sur la Réduction du Wolfram par le Charbon au Four électrique. By Ed. Defacqz. *Comptes rendus hebdomadaires des Séances de l'Académie des Sciences*, 1896, *vol. cxxiii., pages* 1288-1290.

Acting on the results obtained by Prof. Moissan in the reduction of tungstic acid by sugar charcoal in the electric furnace, the author treated a sample of Bohemian wolfram – containing about 72 per cent. of tungstic acid, some 16 per cent. of manganous oxide and from 3½ to 7½ per cent. of ferrous oxide – by mixing it with 14 per cent. of sugar charcoal and exposing for 12 minutes in a Moissan furnace heated by a 950 to 1,000 ampères and 50 to 60 volts current. The fused

of metal was found separated from the scoria by a small quantity of calcium carbide and was therefore easily detached therefrom ; it exhibited a fine-grained fracture, and a degree of hardness similar to that of tungsten carbide. When subjected to analysis it yielded tungsten, silica, iron and carbon, the first-named amounting to about 92·5 per cent. ; carbon 5 per cent. ; iron nearly 2½ per cent., and silica only ½ per cent. The scoria contained nearly 11 per cent. of tungstic acid, along with 88 per cent. of lime, 4 to 4·3 per cent of ferric oxide and rather more than 1 per cent. of silica.

In view of these results, the author is of opinion that the process would be suitable for industrial application for the production of metals from their ores.

C. S.

PREVENTION OF ICE FORMATION IN A DOWNCAST SHAFT.

Note sur le Chauffage, pendant la Saison d'Hiver, de l'Air circulant dans les Puits de Mines, à Parois humides. By PETIT. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1897, *pages* 3-11, *with plates.*

In winter, the current of air drawn into a wet shaft often causes the formation of ice, the quantity of which is increased by infiltrations of water through defective joints in the tubbing, and also by splashes when water is raised by winding. When there is but little clearance between the shaft sides and the cage, the latter may be arrested by the ice unless removed by costly labour while, on a thaw taking place, the fall of ice down the shaft may cause personal accident, and also serious damage to plant.

For combatting these difficulties, the cages containing grates with incandescent coke have sometimes been passed up and down the shaft during the night ; but the mingling of the hot with the cold air is very incomplete, while this arrangement is out of the question in fiery mines. Grates filled with burning coke have also been placed at the mouth of the shaft ; but their action is ineffective, while they are liable to cause fires. The method generally employed is to lead steam down the shaft by a pipe bent into a circle, and pierced with small holes through which the steam escapes ; but, if the quantity of steam be insufficient to raise the temperature in the whole shaft above freezing point, the steam condensed will increase the ice formation, while if it be too great an intense mist will be set up distressing to men working at the landings.

Struck with the many defects of all the methods hitherto employed for counteracting this evil, the author devised a new apparatus for use at the Saint Etienne colliery, Treuil No. 2 shaft, which is now used as a downcast shaft for two distinct districts, one in the No. 11 and the other in No. 13 seam. The shaft is traversed by an air-current of 1,765 cubic feet (50 cubic metres) per second ; and, owing to the slight diameter, there is but little clearance between the sides and the cages. The method adopted consists in raising a portion of the air-volume to such a temperature that the mixture of hot and cold air shall be a few degrees above freezing point ; and the appliance used for effecting this result consists essentially of a group of tubes, round which circulate the gases generated by the combustion of coal charged on a grate, gradually heating the current of cold air which passes through the tubes in the contrary direction, being impelled by a pressure blower.

The tubes, from an old MacNicol boiler, were arranged in three groups connected by flues ; and a Mortier diametral fan of 3 feet (90 centimetres) diameter and the same width was employed. The grate surface, calculated at 27 square feet (2·5 square metres), was increased to 43 square feet (4 square metres) in order to permit of burning inferior coal without having to fire too hard ; and the heating

surface, calculated at 1,850 square feet (172 square metres), was increased to 2,050 square feet (190 square metres), including 1,830 square feet (170 square metres) of tube surface. The furnace-gases, after being directed so as to heat the tubes as uniformly as possible, are led up to the general chimney ; and the cold air, drawn in from the atmosphere by the fan, is blown through the tubes, where it is heated gradually, after which it descends a vertical flue, traverses a horizontal drift that separates into two branches, and is delivered into the shaft 6½ feet (2 metres) below the mouth at each end of a diameter. Two adjustable directing slides oblige each hot-air current to divide, so as to pass round the shaft in two branches, by which means the dangers are avoided that might arise from a jet of hot air being sent directly into the shaft.

After deduction of the price of the fan, which may be used for other purposes 10 months out of the 12, the total cost of the installation is £421 6s. 2d. (10,532 francs 65 centimes) ; and the repairs after each season of using have averaged £16 (400 francs). The mean consumption of inferior coal may be put at 10s. per day, having varied according to the outside temperature between 8s. (10 francs) and 12s. (15 francs). No extra expense is entailed for current labour, because the fan and calorifère are attended to by the winding-enginemen and stokers. The hot-air stove was put up in September, 1894 ; and during the winter of 1894-5—which was excessively severe, since on several days the outside temperature fell to 5° Fahr. (—15° Cent.) it rendered great service, the inside of the shaft having never been covered with ice, as it was during the preceding winter, when winding was interrupted during several shifts. J. W. P.

BALANCING MINE FANS.

Note sur l'Équilibre des Ventilateurs. By A. Godeaux. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1897-98, *series* 3, *vol. vii.*, *pages* 108-110.

In fans driven directly by vertical engines the weight of the piston, cross-head, connecting-rod and crank is not always counterbalanced by a mass diametrically opposed to the crank ; and, if balancing be not effected in another manner, the engine will always, on coming to rest, have a tendency to stop with the dead point downwards, which is inconvenient, and even dangerous for men who have to turn the revolving portion or work about the engine. It is therefore necessary to balance the engine—a practice which also conduces to its easy running—and this may be done by placing a counterweight in the fan itself ; but it may be asked whether, in such a case, this mass will not create disturbance by generating a force tending to bend the shaft, not merely by its weight, but also and especially by the centrifugal force which it sets up.

The author demonstrates mathematically that the moment will be minimum when the radius is maximum, and that it is therefore advisable to place the counterweight at the tips of the vanes. The counterweight thus arranged will give rise to a variable force, and a tendency to deflection will make itself manifest in every direction successively ; but the variations will not be sudden, the passage from one extreme value to the other taking place progressively, while the resultant for a Guibal fan of 30 feet (9 metres) diameter, making 60 revolutions per minute, will only attain about 4 per cent. of the weight of the revolving portion.

The fans at the Mariemont and Bascoup collieries, thus balanced, are far easier to handle than the others, because the effort to be exerted is the same for all positions of the crank, which there is now no longer any difficulty in placing so as to start easily. J. W. P.

MEASURING THE WATER-GAUGE OF FANS.

Sur une Particularité des Mesures du Rendement Industriel des Ventilateurs à l'Aide du Cuvelier en Mine. Parois à l'Air libre. By S. HANAPPE. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1896-97, *series* 3, *vol. vii.*, *pages* 454-458.

The useful dynamic depression of a fan should be measured at the inlet and facing the air-current, no account being taken of the speed of the air issuing from the chimney.

As is wellknown, the ideal exhausting fan is supposed to draw a volume of air Q from an undefined space, and to impel it into another space, also undefined, where the pressure is greater. The difference, H, between these two pressures is the useful load overcome, and is that which should enter into the expression of the useful work. It is this load H, which is given by the formulæ generally used, such as:

$$H + h - \frac{v^2\delta}{g}, \text{ and } H + h - \frac{v_2^2\delta}{2g},$$

in the calculation of which the height $\frac{v_1^2\delta}{2g}$, due to the speed of introduction into the fan, enters with the minus sign; and the theoretical result is here in perfect accordance with logical reasoning.

If it be known that the air issuing from the mine enters every fan at a certain speed, it cannot be asserted that the height due to this speed must be placed to the credit of the fan, because in such case the worst fan would have the greatest advantage. In fact, that one which admits the air at the greatest speed would have the largest term added to its yield, while producing the greatest amount of friction and also of internal disturbance. In fine, the most rational calculation of the useful effect is that based upon the hypothesis of infinite entrance space, and which employs the measurement of the depression taken with the water-gauge tube facing the air-current, being placed not in the inlet itself, but in the fan-drift in front of the entrance to the cone leading to the inlet, if it exist. Accordingly, the best fan is that which, whatever be its construction and arrangement, draws in the same volume of air with the same water-gauge from an infinite entrance space and delivers it into the atmosphere with the least expenditure of mechanical energy. There is no danger that the maker can impute a diminution of useful effect to the mine-owner because fan-drifts are always larger than fan-inlets.

All fans deliver their air into the atmosphere at a certain speed; and, if the height due to this speed be placed to the credit of the fan, the least efficient would again have the advantage. Inasmuch as the best fan would be that delivering the air without speed, there is no reason to take into account the speed with which the air issues when calculating the useful effect. Indeed, after this dissertation, it may be laid down that the best fans are those which draw in and deliver the air with the least speed compatible with the necessities of construction.

The author terminates by a digression as to fan-drifts. It has been asserted that the largest air-chamber in front of the space connected with the inlet is the best; and it is a fact that most modern fans are preceded by a kind of air-chamber or space of more or less considerable size, arranged between the fan-inlet and the fan-drift.

According to Prof. Bélanger's theory, a very large air-chamber causes a loss of load $\frac{v^2\delta}{2g}$, v being the speed of the air in the fan-drift. A straight drift connected progressively with the inlet causes no loss of load; and a drift connected progressively with the inlet by a well-rounded bend causes a loss varying between zero and 0·3 $\frac{v^2\delta}{2g}$.

It follows quite naturally from the above, and in accordance with the principles of rational and experimental mechanics, that the best arrangement of air-chamber in front of a fan-inlet consists in dispensing with an air-chamber altogether; and an ordinary junction, or connexion, well-rounded, would be infinitely preferable.

J. W. P.

CHARACTERISTIC CURVES OF VENTILATORS.

Courbes Caractéristiques des Ventilateurs. *By* S. HANAPPE. *Publications de la Société des Ingénieurs sortis de l'Ecole Provinciale d'Industrie et des Mines du Hainaut*, 1896-97, *series* 3, *vol. vi.*, *pages* 389-408, *with graphic diagrams.*

The author determines theoretically and practically the forms assumed by curves that graphically represent the varying values of the elements or factors of a fan's working in functions of the volume of air delivered and also of the equivalent orifice.

Characteristic Curves in a Function of Volume delivered.

The useful effective depression, or water-gauge, attains a certain value, given by the centrifugal force when the volume is *nil*, and it then increases with the volume owing to the expanding chimney's action, after which it attains zero, when the external resistance is *nil*, and the fan-inlet is open to the atmosphere. Accordingly, the corresponding curve starts from a point in the axis of the ordinates, passes through a maximum and finally attains the axis of the abscissæ for the maximum volume delivered.

The total depression produced by the fan has the same value as the useful depression when the volume delivered is *nil*, and it afterwards increases constantly owing to the effect of the expanding chimney, but very slowly in the case of large volumes. When the inlet is open to the atmosphere, the total depression is at its maximum; but it is entirely absorbed in loss of load due to the appliance itself. The curve characteristic of the total depression rises constantly until the maximum volume is attained.

Inasmuch as the useful power is a product of the volume delivered by the useful depression, it is at first *nil*, and then increases up to a maximum for a certain volume, after which it decreases until zero is attained.

The aero-dynamic power expended, a product of the same volume by the total depression, is also *nil* at first; but it afterwards increases *ad infinitum*.

The aero-dynamic yield, quotient of the powers just mentioned, has the value of zero when the volume delivered is at its maximum, and increases as the volume decreases until a maximum is attained corresponding with the origin of the characteristics for which the two curves of the powers (attaining the origin at the moment they become tangents) give a maximum ratio of ordinates.

The total motive power expended by the fan-engine exceeds the total aero-dynamic power by the value of the mechanical friction, so that its characteristic curve starts from a point in the axis of the ordinates, and rises constantly with the volume delivered.

The transformation yield, quotient of the total aero-dynamic power by the total motive power, has the value of zero at the origin, and increases with the volume, because the two curves of the powers are practically parallel.

The industrial yield, being the quotient of the useful power by the motive power expended, is also the product of the aero-dynamic and transformation yields.

As the curves characteristic of these latter start one from the origin and the other from the axis of the abscissæ, for the maximum volume, and afterwards rise indefinitely, the curve of the industrial yield passes through the zero and maximum abscissæ to attain a maximum value between these two limits.

The equivalent orifice and the temperament increase in direct ratio to the volume delivered, and in inverse ratio to the useful depression. At the origin, the volume is *nil* and the values mentioned zero ; and for the maximum volume the useful depression is also *nil*, and the same values infinite, while between these limits they increase continually. The corresponding characteristic curves, therefore, start from the origin and tend asymptotically towards the ordinate of the maximum volume delivered.

Characteristic Curves in a Function of the Equivalent Orifices.

For the reasons given above, the curve characteristic of the useful depression cuts the axis of the ordinates ; and those characterizing the useful power and the industrial yield start from the origin, while they all pass through a maximum, and then tend asymptotically towards the axis of the abscissæ. In fact, as the equivalent orifice is infinite when the volume delivered is maximum, *i.e.*, with the inlet open to the atmosphere, the useful depression, the useful power and the industrial yield being *nil*, the curves of these latter elements will pass through the axis of the equivalent orifices to the infinite abscissæ.

The curves characteristic of the transformation and aero-dynamic yields start, the first from the origin and the second from the axis of the abscissæ, and then rise constantly. The aero-dynamic power is *nil* at the origin and maximum for an infinite orifice. The total motive power has a certain value due to the mechanical friction at the origin and then increases constantly. The volume, *nil* at the origin, increases indefinitely according to the ordinates of a curve convex as regards the axis of the equivalent orifices.

The author concludes by giving the results of confirmatory experiments, and by comparing the characteristic curves of fans with those of dynamos ; and he draws a parallel, on the one hand, between the characteristic curves of dynamos with constant and independent excitation and those of Guibal type fans ; and, on the other hand, between the characteristic curves of dynamos with compound excitation and those of fans of the Ser and Rateau type. J. W. P.

INTERLOCKING VENTILATION-DOORS.

Note sur un Appareil d'Enclanchement automatique, pour Portes de Mine conjuguées, système Garand. By Botton. *Comptes-Rendus Mensuels de la Société de l'Industrie Minerale*, 1897, *pages* 33-35, *with* 2 *plates*.

In most methods for interlocking ventilating-doors there must be some manipulation for gaining access to the space between them ; but the Garand arrangement is automatic, the doors opening just like ordinary doors, except that they cannot be opened both together. The principle is that of making the opening of a door to depend upon the penetration of a rod forming part of it into a corresponding hole in a disc worked by the other door.

To the inside of each door is firmly fastened an iron rod bent in the form of a circular arc, the centre of which corresponds with the door's axis of rotation. In a vertical plane, at right angles with the door, an iron disc, with but slight clearance between it and the end of the bent rod, turns upon a horizontal axis having a piece

cut out so as normally to permit the curved rod to pass on the door being opened. The disc is, however, connected by a wire-cord with the other door in such a manner that opening the latter causes the disc to turn on its axis, so that the curved rod can no longer pass through the part cut out; the arrangement being the same for both doors.

When, accordingly, a man opens No. 1 door this action will turn the disc connected with it to such a position that No. 2 door cannot be opened until the disc near to it, but connected with No. 1 door, is allowed to resume its normal position on that door being again closed. For ensuring the door's falling to, it is advised not to rely alone upon the hinges being canted, but to add a counterweight. When the distance between the two doors is considerable, the wire-cord may be carried by articulated pulleys like those which support the cord of railway disc-signals; and the method may be applied on curved roads. It may also be employed for interlocking ventilation-doors at the foot of inclines; and its working, which involves no movement on the part of the putter, causes neither obstruction nor delay in the haulage of the tubs. J. W. P.

WINDING FROM GREAT DEPTHS WITH CONSTANT RESISTANCE.

Nouvel Appareil d'Extraction a moment Résistant constant et Tambour cylindrique. *By* André Desprès. *Paris*, 1896, *pages* 1-16.

This new arrangement for winding permits of bringing up minerals from the bottom of a mine with greater security and economy than any method hitherto employed, especially when the depth reaches 3,000 to 3,300 feet (900 or 1,000 metres) and upwards.

In the case of very deep mines, when one of the winding-ropes is completely unwound, the other is completely wound up on the drum; and it follows that the unwound rope, which is of great weight, will exert a pull upon the engine with so much greater force as it is longer, *i.e.* as the shaft is deeper. This tractive effort has a tendency to pull the engine round against the steam, unless it is very powerful.

Various systems have been employed for rendering uniform the effort to be overcome by the engine when making the lift, in order to counterbalance the effort of traction; but, when the above-named depths are attained, these systems have not afforded a uniform tractive effort, even at the expense of great cost and complication. The cost is due to the high price of flat manila ropes when the rope winds up upon itself, or to the cost of the drum when round steel wire-ropes and a spiral drum are employed. The complications consist of (1) fracture of the chains when more than 1,600 feet (500 metres) long, which prevents the employment of systems with chains for great depths; (2) the use of a special drum for raising counterweights or chains; and (3) the difficulty of replacing the flat manila ropes for depths of 3,300 feet (1,000 metres) because they are heavier than steel wire-ropes.

The arrangement in question comprises: (1) A single cylindrical drum the radius of which need not exceed 8 feet 2 inches (2·5 metres) for a shaft 3,300 feet (1,000 metres) deep; and to this drum are attached—one to one edge of the cylindrical surface, and the other to the other edge—the two steel-wire winding-ropes of decreasing section, which are wound in opposite directions, so that

the drum revolving round its axis, one of the ropes is wound up while the other is unwound. The cylindrical surface of the drum occupied by the wound-up portions of the two ropes is always of the same size when the drum revolves on its axis. If, therefore, the width of the drum be made but little—one-fifth only—larger than the space occupied by one only of the ropes, on the drum revolving, the space on the cylindrical portion not covered by the ropes will form a free or empty zone which will be constantly displaced, because one of the ropes is wound up while the other is unwound, leaving the same width for the free or empty zone. Such a drum will therefore be smaller, lighter and cheaper than a spiral drum, because it has a smaller diameter, and the space on the cylindrical portion not occupied by the ropes is also smaller.

(2) A third and endless-rope, which makes two-and-a-half turns round the drum, in the middle of the space just mentioned, left free between the two winding-ropes. When the drum revolves, if the ropes have been arranged as mentioned above, these three ropes will wind up and unwind without fouling one another; and if the cylindrical portion of the drum, instead of being smooth, be covered with a helicoidal groove, forming as many coils as would the wound-up rope plus one-fifth, the three ropes will be guided mechanically. The endless-rope thus wound on the drum is led to the shaft and, after passing over two pulleys—one for the leading and the other for the following end—placed side by side, descends the shaft to half its depth, and is attached to a chain, or fourth rope, the length of which is equal to one-fourth the depth of the shaft, being fastened at a point in the side of the shaft one-fourth of the shaft's depth measured from the two guide-pulleys above-named.

When the drum revolves, the chain is drawn by the endless-rope, sometimes on one side and sometimes on the other, completely counterbalancing the weight of the winding-ropes. The endless-rope should be of diminishing section for reducing the weight. Inasmuch as a hanging steel chain can be 1,650 feet (500 metres) long without breaking, this system of winding may be employed even for shafts 6,600 feet (2,000 metres) deep, because the depth of the shaft may be four times the length of the chain.

This system permits of winding a large quantity of mineral because, as the drum is cylindrical, the speed of lift is constant and, if the speed admitted for the last turns of a spiraloid drum, or of a flat-rope pulley, be taken as the constant speed, the mineral will be wound more quickly; and consequently more will be wound in a given time. The winding-engine may also be less powerful, because it has not to counteract the defect of balancing. J. W. P.

NEW METHOD OF BALANCING WINDING-ENGINES.

Note sur un nouveau Système d'Équilibre des Machines d'Extractions à Tambours cylindriques soustrayant les Câbles d'Extraction à l'Action de leur propre Poids. By ADOLPHE DEMEURE. *Annales des Mines de Belgique*, 1897, *vol. ii., pages* 89-104, *with illustrations.*

The author points out that the first method used in Belgium, was by means of flat ropes of aloe fibre; and among other methods he describes that due to Mr. André Desprès.* This and everal other methods are open to the objection that they keep the weight of the rope uniform, but do not counterpoise it. Several examples of deep shafts show that the weight of the rope is a very serious

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item, exceeding at times the weight of the cage and tubs. For example, for hoisting a gross weight of 11 tons from a depth of 3,723 feet (1,135 metres) the following rope was designed:—Round rope of cast-steel wires, with a breaking strain of 114·3 tons per square inch (180 kilogrammes per square millimetre), consisting of 140 wires and a hemp core, the rope being 2 inches (52 millimetres) in diameter, with a total breaking strain of 182 tons, and weighing about 21·1 lbs. per yard (10·5 kilogrammes per running metre). This would make the total weight to be lifted:—Gross load, 11 tons; weight of rope, 11·9 tons; and total lift, 22·9 tons. Thus giving a coefficent of safety of 7·95, and showing that in spite of the high tensile strength of the steel used, the weight of the rope exceeds that of the load. Even worse results are obtained when aloe fibre is employed. Hence winding from great depths is only possible if the weight of the winding-rope can be counterpoised. This has been effected by Mr. Arthur Lindenberg at the Grimberg pits of the Monopol colliery in Westphalia.

At the Grillo pit of the same colliery, this engineer has introduced a very successful system of balancing the winding-engine though not the weight of the rope. The Grillo shaft is 1,562 feet (476 metres) in depth. The winding-drum is 26¼ feet (8 metres) in diameter, and 13 feet (4 metres) in breadth. The winding-ropes are round steel ropes 1·77 inches (45 millimetres) in diameter. On the main drum is wound a lighter steel rope 0·75 inch (19 millimetres) in diameter, the two ends of which, one at the top, the other at the bottom of the shaft, are attached to a flat steel rope. At either end of this rope are guide blocks running in guides along the walls of the shaft outside of the cages, the rope passing underneath the cages in the sump. The weight of the flat rope is made equal to that of the large and small winding-ropes, so that the weight of the ropes is completely balanced. Thus, when the cage attached, say, to the lower winding-rope is at the shaft-bottom, and winding commences, all the weight of this lower winding-rope, together with that of the small rope, oppose the lift of the engine, whilst the entire weight of the flat balance-rope is acting with the engine; as the large and small winding-ropes are wound up less of the flat balance-rope is at liberty to resist the engine and the balance is perfect. This system was applied to an existing shaft, and works well, the speed of winding being 32¾ feet (10 metres) per second.

At the Grimberg pit, the weight of the rope is completely counterpoised; instead of the small ropes passing round the drum they pass over a pair of pulleys situated just above the winding-rope pulleys, and are attached to the cages. The weight of the flat balancing-rope must, therefore, be that of the winding-rope plus twice that of the small rope. In this arrangement, the weight of the winding-ropes is completely balanced, and in any position of the cages the winding-rope has only to support the weight of the cage less that of one small rope. The limiting condition is that the weight of each small rope must not exceed that of the empty cage.

The Grimberg shaft is 2,542 feet (775 metres) deep, the bottom flat-sheets being at a depth of 2,526 feet (770 metres), and the top ones at 23 feet (7 metres) above the ground, the centre of the winding-pulleys being 79 feet (24 metres) above the former. The axis of the winding-drum is at a horizontal distance of 164 feet (50 metres). The diameter of the shaft is 16½ feet (5 metres); the guides are of wood, and the speed of winding is high, exceeding 33 feet per second. The winding-engine is a horizontal compound engine, taking steam at 105 to 120 lbs. (7 to 8 atmospheres). The cylinders are 35½ inches (0·9 metre) and 55 inches (1·4 metres) respectively in diameter, with a stroke of 86½ inches (2·2 metres). The drum is

26¼ feet (8 metres) in diameter and 13 feet (4 metres) in breadth, and it can take 3,280 feet (1,000 metres) of round rope 1·38 inches (35 millimetres) in diameter. In addition to the two winding-ropes, two small ropes and a balance-rope are required, but it would appear that the sum of the weights of all these ropes is less than that of an unbalanced winding-rope.

The main advantages are that the inertia of all the balancing-ropes is not transmitted to the drum, and thus does not affect the engine, which is easily handled. The winding-rope need only be strong enough to carry the full cage, and may be worked to any depth with a uniform section.

The result of the breakage of the small rope would be to throw much extra strain on the winding-rope, but should not break the latter, as it will always be well below its tensile strength; nevertheless, the small ropes will need careful looking after. H. L.

TWO MEN AT THE WINDING-ENGINE.

Travaux des Ouvriers dans les Mines. Belgian Royal Decree. *Annales des Mines de Belgique*, 1898, *vol. iii., page* 155.

While men are being wound in mine-shafts, an assistant, capable of continuing the lift or of stopping the engine in the event of sudden indisposition to the engineman, must remain within reach of the starting and reversing levers; and he must, like the engineman, concentrate his attention on the signals and on the working of the engine, while everything of a nature to distract this attention is strictly forbidden. Exemptions from the first provision of this decree may be granted by the provincial councils, acting on the report of the chief inspectors of mines (*ingénieurs en chef, directeurs d'arrondissement*); and contraventions will be dealt with under the law of 1810 as to mines, open-workings, quarries and works. J. W. P.

WINDING-ENGINE VALVES.

Note sur les Modérateurs de Machines d'Extraction. By V. Godeaux. *Publications de la Société des Ingénieurs sortis de l'Ecole Provinciale d'Industrie et des Mines du Hainaut*, 1897-98, *series* 3, *vol. viii., pages* 101-107, *with diagrams.*

Modern winding-engines are generally fitted with balanced double beat valves; but older engines were often made with slide-valves, that require considerable effort to open, and for large powers cause great fatigue to the engine-man. The following is a cheap and simple method, easily applied, for considerably diminishing the effort necessary to work slide-valves.

The hand-gear consists of a two-armed lever in the ratio of about 4 to 1, acting through a connecting-rod on the slide-valve. As the position of the rod differs but little from the horizontal, the effort to be exerted is at its maximum at the beginning of the pull, and diminishes as the port is uncovered, because the steam pressures above and below the slide have a tendency to balance one another. The effort required for starting may be reduced by keying the lever arms so as to form a very obtuse angle towards the slide-valve, instead of keeping them in the same straight line; and this angle, depending upon the conditions of each case, may be determined in accordance with the muscular force of the engine-

man. Increasing the angle made by the short arm with the long arm produced will, however, increase the distance through which the handle of the starting lever must be pulled, unless the length of the short arm be also increased in accordance with requirements.

In a vertical winding-engine at the Sainte-Henriette shaft of the Mariemont colliery it was found so difficult to work the slide-valves that the above arrangement was applied in 1891. In this case it was not found necessary to increase the length, 4 inches (10 centimetres), of the short arm ; but it was shifted forward to an angle of about 50 degrees, when the pull on the starting lever was diminished by 43 per cent. on starting and 24 per cent. afterwards. Inasmuch as with this change, the port is not uncovered so suddenly as before, owing to the diminished effort required, the men can handle their engine more easily during the changing at bank and at the underground landings, in addition to their fatigue being greatly diminished, although the handle of the starting-lever has now to be drawn through 3 feet 4 inches (1·025 metres), instead of 2 feet 2 inches (0·67 metre) as before, for the same uncovering of the port. In several winding-engines at the Mariemont colliery, the regulators have been modified in this manner with good results. J. W. P.

RENEWAL OF SHAFT-GUIDES WITHOUT STOPPAGE TO WINDING.

Charbonnages de l'Espérance et Bonne-Fortune, Siège Bonne-Fortune : Remplacement du Guidonnage. By E. Fineuse. *Annales des Mines de Belgique*, 1897, *vol. ii., page* 909.

Inasmuch as the cage frequently left the guides when the speed exceeded 50 feet (15 metres) per second, it was decided to replace the old flat bar guides by flange rails weighing 36 lbs. per yard (18 kilogrammes per metre), bolted to the buntons by two pieces of steel clamping the flanges ; and the new guides were laid inside the old without interruption to the winding for a single day, the 1,155 feet (352 metres) having been fixed on Sundays within a period of 6 months. For fixing the guides, a platform was hung from the winding-rope by four chains 20 feet (6 metres) above the cage-cover ; and a movable *parapierre*, or protection against stones, was fastened to the rope above the heads of the men, two of whom took up their position on the cage-cover and the two others on the flying cradle. The rails were let down upright, their lower ends resting on the cage-cover, while they were held by the men on the cradle. When the place was reached where the rails were to be placed they were hitched on to a differential pulley and, when they were brought to their definite position, the men, who were attached by a belt and safety-chain, fastened them at both ends simultaneously. J. W. P.

MOUSTIER SAFETY-CAGE.

Note sur le Parachute Brunot Moustier. By — Vallat. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1897, *pages* 21-23, *with* 1 *plate*.

In nearly all the safety-cages now in use the force for retarding the falling cage depends upon a spring's action, which may become insufficient owing to the constant strain to which it is subjected ; but in the Moustier arrangement the spring has only to push forward a fork or bolt so as to clamp the guides, while the force need only be just sufficient to push this fork out of its recess.

In the case of timber guides, their sides are fitted at intervals of 5 feet to 7 feet (from 1·5 to 2 metres) with inclined plates of wrought-iron about 20 inches (50 centimetres) long, of about one-third the width of the guides and sufficiently thick to ensure the clamping of the forked bolts, which seize the two side faces of the guides and so pull up the cage, while in normal working they are kept clear of the plates. Horizontal spiral springs of no great strength, attached to the end of the winding-rope push out, on the latter breaking, the forked bolts, the cheeks of which become gradually wedged along the first inclined plane they encounter. The cage would fall through at most 5 feet (1·5 metres) if the inside face of the forked bolts were not provided with claws, which engage in the corresponding face of the guides, setting up a resistance which greatly lessens the speed of fall; and complete arrest of the cage is then effected by the gradual wedging. When the shaft-guides are formed of rails, the arrangement of the inclined plane is the same; but the bolt is made to follow the form of the rail-head.

The following advantages are claimed for this arrangement:—(1) The spring, not having to support the weight of the cage, is in a better condition to act efficiently; (2) its action is progressive so as not to strain the guides or run the risk of breaking them; (3) the parts are simple, not liable to deterioration and easily lubricated; and (4) the spring is not sufficiently strong to bring the catch into action when not required. J. W. P.

LAPORTE SAFETY-CAGE.

Note sur le Parachute Laporte. By — BADIN. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1897, *pages* 121-122, *with* 1 *plate*.

This safety appliance, which is applied to two shafts, one fitted with iron and the other with steel guides, at the Malfidano mines in Sardinia, differs from other similar arrangements in having two separate sets of catches, that are projected outwards by the release of a spiral spring on the rope breaking, one set acting as a powerful brake against the face of the rail guides, so as to retard the descent of the cage, and the other set definitely arresting it by engagement of the catches upon the buntons, which are spaced about 4 feet (from 1 to 1½ metres) apart, so that the cage may not have too great a distance to fall, notwithstanding the brake action exerted by the other set of catches. When, as is the case at the Malfidano mines, the winding compartment is enclosed by complete timber frames, the two sets of catches are arranged at right angles to one another; but in the case of circular shafts, in which the rail-guides are bolted to the buntons, one set must be arranged above the other. When the communication was made to the society, the safety catches had not once come into operation; but a demonstration was made before the members with a model one-tenth actual size, and a cage weighted in proportion. On the rope being cut, it was found that the action of the braking claws was so intense that the cage came to rest, through the other pair of catches engaging with the buntons, without the slightest shock.

J. W. P.

II.—BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEAR 1897.

By M. WALTON BROWN.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of Glasgow and Kew Observatories, and give some idea of the variations of atmospheric temperature and pressure in the intervening districts in which mining operations are chiefly carried on in this country.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of 0·150 inch to each reading, and the barometrical readings at both observatories are reduced to 32° Fahr.

The statistics of fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are also printed upon the diagrams (Plates XIX. and XX.) recording the meteorological observations.

Table I.—Summary of Explosions of Fire-damp or Coal-dust during 1897, in the several Inspection Districts.

	Fatal Accidents.			Non-fatal Accidents.	
	No.	Deaths.	Injured.	No.	Injured.
Durham	0	0	0	2	2
Liverpool	0	0	0	1	3
Manchester and Ireland	0	0	0	0	0
Midland	1	1	0	4	9
Newcastle-upon-Tyne ...	0	0	0	13	15
Scotland, East	3	4	2	28	37
Do. West	2	2	4	39	51
South Wales	2	6	0	33	42
South-Western	1	1	0	0	0
Staffordshire, North ...	0	0	0	2	2
Do. South ...	2	2	1	6	6
Yorkshire	1	3	1	8	10
Totals	12	19	8	136	177

TABLE II.—LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES DURING 1897.

1897.	Colliery.	Inspection District.	Deaths.	No. of Persons Injured.
Jan. 5, 5·0 a.m.	Broadoak	South Wales ...	5	0
Mar. 12, 9·30 p.m.	Bothwell Park (No. 1)	Scotland, West ...	1	4
,, 18, 7·40 a.m.	Knowle	Staffordshire, South...	1	0
April 1, 6·40 p.m.	Gadlys	South Wales ...	1	0
May 13, 1·45 ,,	Darngavil	Scotland, East ...	2	1
July 3, 6·50 a.m.	Dalmeny (Oil-shale)	Do. ..	1	1
Aug. 9, 6·30 p.m.	Ravensthorpe (or Calder)	Yorkshire	3	1
Sept. 29, 8·15 ,,	Drumpeller (Nos. 3 and 4)	Scotland, West ...	1	0
Oct. 11, 1·15 ,,	Newliston (Oil-shale)	Scotland, East ...	1	0
Nov. 29, 10·30 a.m.	Alvecote, Tamworth	Midland	1	0
Dec. 10, 12·30 p.m.	East Cannock ..	Staffordshire, South...	1	1
,, 20, 7·0 a.m.	Blaendare Slope ...	South-Western ...	1	0
		Totals ...	19	8

TABLE III.—LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES DURING 1897.

1897	Colliery.	Inspection District.	No. of Persons Injured.
Jan. 7, 1·45 p.m...	South Rhondda ..	South Wales	1
.. 8, 10·0 a.m....	River Level	Do.	1
.. 12, 3·30 p.m....	Abercrave	Do. ...	2
.. 13, 2·45 a.m....	Tanfield Moor ...	Newcastle-upon-Tyne	1
,, 21, 8·0 p.m....	Cymmer Glyncorrwg...	South Wales	1
.. 25, 10·45 a.m....	Thankerton (No. 4) ..	Scotland, West ..	2
.. 27, 6·0 ,, ..	Sands	Staffordshire, North ..	1
Feb. 2, 6·30 p.m....	Cwrt-y-bettws ..	South Wales	2
,, 3, 12·30 ,, ...	Brownyside	Scotland, East ...	1
.. 4, 1·30 ,, ...	Garrockhill	Scotland, West ..	1
.. 16, 2·0	Fergushill (No. 28) ..	Do. ...	1
.. 18, 1·0 ,, ...	Barrwood (No. 1) ..	Do.	1
.. 18, 2·0	Llest	South Wales	1
.. 19, 7·30 a.m. .	Darngavil	Scotland, East ...	1
,, 20, 10·30 p.m. .	Preston...	Newcastle-upon-Tyne	1
.. 24, 11·45	White Lea	Durham	1
Mar. 2, 4·0	Skellyton	Scotland, East ...	2
.. 3, 4·45 a.m.	Kibblesworth... ...	Newcastle-upon-Tyne	1
,, 9, 8·50 ,, ...	Pumpherston (Oil-shale)	Scotland, East ...	1
.. 11, 11·30 ,, ..	Lanemark (No. 2) ...	Scotland, West ..	1
,, 11, 7·30 p.m.	Llest	South Wales	1
.. 15, 1·0 ..	Straiton (Oil-shale) ...	Scotland, East ...	1
,, 17, 9·30 ,, ...	Lanemark (No. 2) ...	Scotland, West ...	1
,, 25, 1·0 .. .	South Rhondda ...	South Wales	1
,, 26, 12·0 noon...	Park	Do. ...	1
April 1, 6·0 a.m. ..	South Medomsley ...	Newcastle-upon-Tyne	1
.. 1, 6·20 ,, ..	Greenfield, Threestone-hill (No. 7) ...	Scotland, West ...	2
,, 8, 11·30 ,, ..	Dark Lane	Yorkshire	1
,, 8, 12·30 p.m....	Monkland	Scotland, East ...	1

TABLE III.—*Continued.*

1897.			Colliery.	Inspection District.	No. of Persons Injured
April	9.	1·30 p.m....	Westminster	Liverpool	3
,,	9.	7·0 ,, ...	Aldridge	Staffordshire, South ...	1
,,	12.	11·30 a.m....	Cornsilloch	Scotland, East ...	1
,,	17.	2·0 p.m....	Oatlands ...	Newcastle-upon-Tyne	2
,,	24.	11·0 a.m...	Cannock Chase ..	Staffordshire, South ...	1
,,	29.	9·45 ,, ...	Hazelrigg	Newcastle-upon-Tyne	1
,,	29.	1·0 p.m...	Stocksbridge	Yorkshire ...	1
,,	30.	9·0 ,, ...	Blairhall ...	Scotland, East ..	1
May	6.	7·15 a.m....	Dalziel (No. 2) ..	Scotland, West	1
,,	7.	4·0 ,, ...	Abercrave	South Wales	1
,,	11.	7·30 ,, ...	Polbeth (Oil-shale) ..	Scotland, East ...	1
,,	14.	8·0 ,, ,,	Neilston (No. 3) ...	Scotland, West ..	2
,,	17.	11·0 ,, ...	Dalziel (No. 1) ...	Do. ...	1
,,	20.	12·0 m'night	Coilena	South Wales	1
,,	22.	8 0 a.m....	Barblues	Scotland, East ...	1
,,	24.	8·30 ,, ...	Strawberry Bank ...	Yorkshire	2
,,	25.	1·0 p.m....	Camp (No. 1) ...	Scotland, West ...	2
,,	26.	11·30 a.m....	Barblues	Scotland, East ...	1
,,	26.	12·30 noon...	Abercrave	South Wales	2
,,	27.	2·30 a.m....	Darranfawr	Do. ...	4
,,	29.	12 noon ...	Cannock Old Coppice	Staffordshire, South ...	1
June	16.	7·30 a.m....	Bebside	Newcastle-upon-Tyne	2
,,	16.	10·0 ,, ...	Clara Vale	Do. ...	1
,,	28.	1·0 p.m....	Tinockley ...	Do. ...	1
,,	29.	11·0 ,, ...	Pemberton	South Wales	1
July	3.	9·0 a.m....	St. John's	Yorkshire	1
,,	5.	1·30 p.m.	Birkrigg ...	Scotland, East ..	2
,,	5.	3·0 ,, ...	Woodhall (No. 1) ...	Scotland, West ..	1
,,	5.	4·30 ,, ...	Tannochside (No. 3) ...	Do. ..	3
,,	6.	5·0 ,, ,,	Gwaun Clawdd ...	South Wales	1
,,	7.	11·30 a.m....	Forkneuk (Oil-shale)..	Scotland, East ...	1
,,	9.	7·0 ,, ...	Hazlehead	Yorkshire	1
,,	10.	5·50 ,, ...	Prestongrange ..	Scotland, East ...	1
,,	13.	1·30 p.m....	Primrose	South Wales	1
,,	14.	11·0 a.m....	Glynea... ...	Do. ...	1
,,	15.	3·0 p.m....	Gartsherie (No. 1) ...	Scotland, West ...	1
,,	23.	12·0 noon	Montgomeriefield (No. 2	Do. ...	2
,,	26.	10·0 a.m....	Brownyside	Scotland, East ...	1
Aug.	1.	10·0 p.m....	Lletty Shenkin ...	South Wales	3
,,	2.	3·0 a.m....	Bebside	Newcastle-upon-Tyne	1
,,	3.	8·0 ,, ...	Glengarnock (No. C)	Scotland, West ...	1
,,	11.	8·30 ,, ...	Rankinston (No. 2) ..	Do. ...	1
,,	16.	9·0 ,, ,,	Addiewell (Oil-shale)..	Scotland, East ...	1
,,	17.	9·0 ,, ...	Blairhall	Do. ...	1
,,	26.	3·30 p.m....	Cornsilloch	Do. ...	1
,,	30.	6·15 a.m....	Roman Camp (Oil-shale	Do. ...	1
Sept.	1.	10·0 ,, ,,	Merryton	Do. ...	3
,,	2.	11·0 ,, ...	Springhill (No. 3) ...	Scotland, West ...	2
,,	6.	10·0 ,, ...	Gelynog	South Wales	1
,,	10.	11·30 ,, ...	Milnwood (No. 1) ...	Scotland, West ...	2
,,	13.	6·0 ,, ...	Holytown (No. 5) ...	Do. ...	1
,,	17.	7·45 ,, ,,	Coppice	Staffordshire, South ...	1
,,	17.	3·30 p.m....	Brynhenllis	South Wales	1
,,	25.	6·45 a.m....	Bourtreehill, Capring-stone (No. 7) ..	Scotland, West ...	1
,,	28.	6·0 p.m....	Gateside (No. 2) .	Do. ..	1
Oct.	1.	3·45 ,, ...	Cynheiog ...	South Wales	1
,,	2.	10·15 a.m....	Kenmuirhill (No. 4) ...	Scotland, West ...	1
,,	5.	12·30 p.m....	Bullhouse	Yorkshire	1
,,	8.	7·30 ,, ...	Blackwell	Midland	3
,,	9.	2·0 a.m....	Clydach Merthyr ...	South Wales ...	1

TABLE III.—*Continued.*

1897			Colliery.	Inspection District.	No. of Persons Injured.
Oct.	9,	7·20 a.m.	Hanwood	Staffordshire, North	1
..	9,	8·0 ..	Newbattle	Scotland, East	4
..	9,	8·30 ..	Coneygre	Staffordshire, South	1
..	11,	7·0 ..	Law	Scotland, East	2
..	11,	10·30 p.m.	Souterhouse (No. 2)	Scotland, West	1
..	15,	10·0 a.m.	Common (No. 16)	Do.	1
..	22,	8·0 „	Backworth	Newcastle-upon-Tyne	1
..	22,	11·30 „	Bryn Navigation	South Wales	1
..	22,	3·0 p.m.	Primrose	Do.	1
..	25,	9·45 a.m.	Great Wyrley	Staffordshire, South	1
..	27,	1·0 „	Gartshore (No. 11)	Scotland, West	1
..	28,	3·0 p.m.	Cornsilloch	Scotland, East	2
Nov.	3,	1·0 a.m.	Velinfran	South Wales	1
..	4,	8·0 p.m.	Llest	Do.	2
..	5,	7·0 a.m.	Drumpeller (No. 4)	Scotland, West	2
..	5,	10·40 „ ..	Llynfi Valley	South Wales	1
..	5,	6·30 p.m.	Blantyre (No. 4)	Scotland, West	1
..	8,	2·30 „ ..	Blackston	Do.	1
..	9,	12·45noon	Gwaun Clawdd	South Wales	1
..	10,	11·0 a.m.	Hartshay	Midland	1
..	11,	7·0 „	Souterhouse (No. 1)	Scotland, West	1
..	12,	5·15 „	Foxley (No. 3)	Do.	1
..	12,	7·0 p.m.	Seaton Burn	Newcastle-upon-Tyne	1
..	13,	7·5 a.m.	South Duffryn	South Wales	1
..	18,	2·30 p.m.	Pye Hill	Midland	3
„	22,	7·0 a.m.	Holytown (No. 5)	Scotland, West	1
..	22,	9·0 „	South Rhondda	South Wales	1
..	23,	5·0 „	Deep Navigation	Do.	1
..	25,	3·0 „	Darranfawr	Do.	1
..	25,	9·0 p.m.	Glenboig (Fire-clay)	Scotland, East	1
..	29,	6·0 a.m.	Kirkhill	Scotland, West	1
..	30,	10·0 „	Common (No. 16)	Do.	1
Dec.	3,	9·0 p.m.	Churwell	Yorkshire	1
..	6,	3·0 „	Parkhead	Scotland, West	2
..	7,	8·0 „	Bent	Scotland, East	1
..	16,	1·0 „	Pye Hill	Midland	2
..	18,	11·30 a.m.	Ayr, Drumley (No. 1)	Scotland, West	1
..	20,	2·45	Railey Fell	Durham	1
..	20,	6·15	Rosewell	Scotland, East	1
..	24,	12·45 p.m.	Cornsilloch	Do.	1
..	26,	10·15	Hattonrigg (No. 3)	Scotland, West	2
..	27,	10·0 a.m.	Daldowie	Do.	1
..	27,	12·30noon	Cramlington	Newcastle-upon-Tyne	1
..	29,	1·30 a.m.	Dyllas	South Wales	1
..	29,	2·0 p.m.	Grange Ash	Yorkshire	2
..	31,	1·0 a.m.	Parkhead	Scotland, West	1
..	31,	6·40 a.m.	Pumpherston (Oil-shale)	Scotland, East	1
				Total	177

TABLE IV.—BAROMETER THERMOMETER, ETC., READINGS. 1897.

JANUARY, 1897.

	KEW.							GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·181	30·355	30·435	30·516	48·2	28.0	N	1	29·998	30·169	30·265	30·303	43·5	37·3	SW
2	30·531	30·549	30·494	30·439	36·6	26·6	N	2	30·285	30·249	30·183	30·138	45·6	37·0	SSW
3	30·338	30·310	30·247	30·212	44·4	35·1	S	3	30·039	29·941	29·817	29·830	45·4	40·6	SSE
4	30·161	30·126	30·056	30·009	39·2	34·2	SSW	4	29·833	29·816	29·810	29·779	43·4	38·9	SW
5	29·956	29·953	29·875	29·823	42·7	36·7	S	5	29·739	29·783	29·749	29·703	43·4	36·5	SSW
6	29·716	29·687	29·623	29·623	46·3	35·3	SE	6	29·652	29·654	29·677	29·740	41·8	35·7	ESE
7	29·613	29·738	29·726	29·701	47.8	42·1	ESE	7	29·761	29·805	29·849	29·940	42·1	38·1	E
8	29·679	29·635	29·605	29·638	42·9	40·7	E	8	29·931	29·962	29·947	29·974	40·2	38·0	E
9	29·635	29·618	29·520	29·491	42·8	36·7	NE	9	29·927	29·847	29·714	29·588	39·3	30·6	E
10	29·501	29·591	29·604	29·652	47·1	40·1	ENE	10	29·538	29·572	29·608	29·660	36·3	29·8	E
11	29·668	29·703	29·719	29·732	42·7	38·0	NE	11	29·667	29·677	29·670	29·676	38·7	34·8	ENE
12	29·722	29·718	29·678	29·693	41·2	39·7	N	12	29·658	29·681	29·714	29·797	40·5	36·5	ENE
13	29·733	29·823	29·879	29·972	40·2	37·8	NE	13	29·893	30·006	30·074	30·190	38·2	34·4	NE
14	30·040	30·143	30·157	30·150	40·1	34·7	N	14	30·237	30·275	30·277	30·286	39·0	28·4	W
15	30·123	30·105	30·027	30·001	38·8	32·1	N	15	30·270	30·253	30·161	30·105	37·5	28·5	N
16	29·947	29·957	29·924	29·935	34·8	31·0	NE	16	30·024	29·996	29·961	30·004	35·4	31·1	S
17	29·923	29·975	30·013	30·063	34·6	27·8	NW	17	30·023	30·075	30·064	30·053	33·8	25·3	SW
18	30·073	30·091	30·053	30·057	34·7	23·8	SW	18	30·030	30·062	30·074	30·117	32·7	23·7	E
19	30·044	30·056	30·013	30·036	37·2	32·2	N	19	30·151	30·212	30·231	30·268	38·4	30·4	NE
20	30·053	30·115	30·079	30·072	36·8	30·5	ENE	20	30·312	30·344	30·321	30·296	39·1	35·5	ENE
21	30·007	29·960	29·800	29·612	34·2	30·2	NE	21	30·199	30·038	29·780	29·663	39·0	28·1	SW
22	29·391	29·367	29·368	29·523	35·6	26·1	N	22	29·695	29·753	29·874	29·960	38·5	30·6	NNE
23	29·594	29·661	29·804	29·916	31·0	26·4	N	23	29·973	30·080	30·097	30·062	34·2	27·0	NE
24	29·900	29·909	29·809	29·706	33·0	25·1	NW	24	29·905	29·710	29·537	29·462	39·7	25·1	SW
25	29·597	29·583	29·531	29·657	39·7	30·0	W	25	29·399	29·491	29·468	29·457	38·8	24·1	SW
26	29·707	29·731	29·757	29·810	35·8	28·9	W	26	29·511	29·575	29·623	29·660	32·5	24·6	WNW
27	29·827	29·892	29·974	30·105	38·9	27·5	NW	27	29·770	29·948	30·034	30·079	40·1	28·4	NNW
28	30·119	30·107	30·040	30·029	37·4	30·0	W	28	30·054	30·063	30·044	30·012	38·0	32·0	NW
29	29·984	29·947	29·827	29·687	37·8	31·1	WNW	29	29·949	29 848	29·665	29·485	35·3	29·1	SW
30	29·450	29·254	29·187	29·275	38·5	34·1	E	30	29·330	29·290	29·205	29·214	33·5	30·0	E
31	29·283	29·400	29·505	29·483	37·1	34·5	NE	31	29·251	29·233	29·274	29·323	38·0	30·1	W

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1	29·371	29·299	29·323	29·296	38·1	33·4	E	1	29·318	29·318	29·320	29·313	35·0	30·0	E
2	29·146	29·165	29·346	29·474	37·6	34·1	NE	2	29·259	29·287	29·361	29·503	35·3	32·1	E
3	29·605	29·761	29·797	29·798	40·1	34·2	SE	3	29·615	29·725	29·752	29·780	35·3	30·3	E
4	29·797	29·834	29·804	29·753	47·8	40·1	SW	4	29·780	29·779	29·726	29·681	36·4	31·1	E
5	29·631	29·437	29·216	29·322	46·5	37·6	ESE	5	29·596	29·556	29·494	29·494	38·8	32·7	E
6	29·459	29·509	29·426	29·553	40·1	36·7	NW	6	29·489	29·500	29·511	29·608	37·9	35·1	E
7	29·711	29·887	30·035	30·176	41·7	32·9	N	7	29·713	29·872	29·976	30·040	39·0	35·0	SE
8	30·270	30·280	30·228	30·102	44·0	31·3	S	8	30·013	29·973	29·857	29·630	43·4	36·9	SSW
9	29·974	29·976	29·946	30·037	51·3	44·1	SW	9	29·588	29·626	29·723	29·855	45·9	38·7	W
10	30·082	30·165	30·113	30·086	50·0	44·9	NE	10	29·928	30·020	30·015	30·037	41·0	35·0	W
11	30·032	30·057	30·057	30·107	46·0	40·8	E	11	30·034	30·073	30·075	30·134	35·9	26·3	NNE
12	30·126	30·178	30·151	30·155	42·2	38·6	E	12	30·132	30·128	30·058	30·004	37·1	26·8	E
13	30·100	30·036	29·946	29·917	48·0	38·9	E	13	29·890	29·827	29·757	29·760	43·1	34·4	ENE
14	29·909	29·984	30·030	30·132	51·9	45·2	NW	14	29·776	29·862	29·938	30·058	46·1	39·2	W
15	30·195	30·299	30·379	30·512	46·8	39·4	N	15	30·153	30·259	30·329	30·387	46·8	36·5	W
16	30·566	30·610	30·571	30·565	44·9	37·3	SSW	16	30·400	30·402	30·371	30·353	46·5	41·2	SW
17	30·510	30·514	30·423	30·391	47·4	30·0	SW	17	30·327	30·319	30·207	30·107	45·4	42·0	SW
18	30·308	30·299	30·229	30·265	51·6	28·1	S	18	29·985	29·857	29·727	29·887	46·9	41·7	SSW
19	30·245	30·265	30·241	30·238	49·8	43·8	SSW	19	29·913	29·929	29·898	29·865	52·1	42·2	WSW
20	30·169	30·169	30·224	30·190	53·3	44 7	SW	20	29·837	29·895	29·875	29·521	50·3	43·0	WSW
21	30·124	30·320	30·444	30·514	51·1	44·7	WSW	21	29·899	30·139	30·247	30·282	46·7	39·1	WNW
22	30·518	30·573	30·552	30·592	55·1	46·0	WNW	22	30·308	30 336	30·360	30·393	50·6	44·8	WSW
23	30·582	30·599	30·557	30·572	53·1	44·3	WSW	23	30·315	30·241	30·148	30·276	49·9	44·7	SW
24	30·569	30·572	30·432	30·394	49·4	46·0	SW	24	30·277	30·112	29·810	29·856	47·4	40·9	SW
25	30·260	30·179	30·115	30·140	50·5	47·0	WSW	25	29·685	29·463	29·500	29·571	52·7	43·2	SW
26	30·143	30·186	30·149	30·191	56·3	48·0	W	26	29·598	29·656	29·626	29·850	53·3	42·3	SW
27	30·215	30·313	30·264	30·266	51·2	38·7	NNE	27	29·992	30·068	30·083	30·057	44·0	37·6	WSW
28	30·137	29·989	29·767	29·611	49·2	35·2	SSW	28	29·938	29·726	29·403	29·226	43·8	35·6	SSE

MARCH, 1897.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·505	29·535	29·494	29·480	49·0	36·9	WSW
2	29·644	29·770	29·650	29·102	46·6	35·1	W
3	28·792	28·762	29·199	29·357	48·0	35·3	WNW
4	29·548	29·589	29·169	29·203	49·2	35·8	SW
5	29·217	29·291	29·344	29·407	47·1	35·0	WSW
6	29·476	29·627	29·754	29·886	44·9	36·0	NNE
7	29·935	30·038	30·057	30·104	43·1	34·2	E
8	30·087	30·119	30·084	30·115	45·7	31·3	NE
9	30·080	30·077	29·996	29·997	47·3	30·3	S
10	29·871	29·948	29·974	30·052	49·0	37·7	W
11	30·059	30·050	29·888	29·639	49·9	32·9	SSW
12	29·535	29·578	29·592	29·558	49·0	33·2	W
13	29·509	29·547	29·565	29·586	46·0	33·9	NE
14	29·524	29·418	29·339	29·222	45·2	37·7	SSE
15	29·266	29·302	29·293	29·438	48·2	40·0	SSW
16	29·471	29·491	29·397	29·445	52·5	38·9	SW
17	29·445	29·482	29·492	29·387	52·2	42·2	SW
18	29·481	29·498	29·698	29·851	53·5	41·1	W
19	29·697	29·839	29·853	29·973	55·1	44·7	W
20	30·030	30·139	30·094	30·091	56·9	43·1	W
21	30·048	30·026	30·088	30·105	60·2	48·0	W
22	30·058	30·007	29·859	29·818	56·4	50·1	SW
23	29·871	29·981	29·916	29·884	60·9	44·8	W
24	29·764	29·773	29·832	29·913	57·9	46·0	W
25	29·969	30·033	30·029	30·042	57·0	46·4	WNW
26	29·961	29·892	29·643	29·576	55·8	49·0	SW
27	29·548	29·652	29·712	29·712	54·8	47·1	WNW
28	29·538	29·281	29·140	29·190	55·8	42·3	SW
29	29·390	29·451	29·526	29·559	47·0	39·4	NNW
30	29·568	29·619	29·573	29·534	51·1	30·6	WSW
31	29·430	29·344	29·234	29·182	53·9	38·8	SSW

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·151	29·154	29·200	29·298	43·2	35·0	WSW
2	29·350	29·387	28·973	28·881	38·5	33·6	S
3	28·705	28·856	28·947	29·162	44·5	31·1	NW
4	29·170	28·834	28·714	28·732	41·8	33·3	SE
5	28·814	28·948	29·101	29·333	42·9	31·0	W
6	29·514	29·705	29·819	29·940	46·3	35·1	NNW
7	29·985	30·031	30·007	30·020	45·8	36·0	ESE
8	29·982	29·985	29·926	29·865	44·0	34·0	SE
9	29·781	29·762	29·689	29·581	47·4	40·7	SSW
10	29·503	29·587	29·687	29·741	44·8	35·2	WSW
11	29·762	29·764	29·652	29·555	46·1	35·6	S
12	29·385	29·277	29·241	29·302	43·2	33·2	E
13	29·323	29·370	29·386	29·424	41·8	34·7	SE
14	29·448	29·480	29·494	29·530	40·7	35·2	ESE
15	29·437	29·345	29·213	29·194	39·4	33·8	NE
16	29·201	29·161	29·038	29·068	45·8	38·3	ESE
17	29·097	29·052	28·936	28·923	49·6	40·6	SSW
18	28·974	29·059	29·297	29·379	48·6	41·3	WSW
19	29·341	29·386	29·569	29·718	49·0	40·1	W
20	29·999	29·988	29·946	29·877	47·8	37·9	ESE
21	29·896	29·907	29·883	29·889	52·6	39·5	SSW
22	29·829	29·863	29·319	29·307	51·1	40·2	S
23	29·483	29·635	29·642	29·502	51·7	45·7	W
24	29·263	29·164	29·317	29·497	50·5	46·1	WSW
25	29·580	29·729	29·801	29·827	51·6	44·7	W
26	29·654	29·318	29·135	28·871	52·1	43·1	SW
27	29·109	29·244	29·325	29·395	49·3	43·3	WSW
28	29·252	29·077	29·037	29·137	44·8	34·2	NE
29	29·249	29·302	29·474	29·528	41·3	33·4	N
30	29·549	29·539	29·468	29·402	37·2	27·8	SW
31	29·382	29·390	29·339	29·306	42·0	28·2	NE

APRIL, 1897.

1	28·996	28·999	29·146	29·298	43·2	34·9	NNE
2	29·439	29·674	29·732	29·725	46·0	36·8	NW
3	29·597	29·505	29·356	29·241	44·3	34·3	ESE
4	29·274	29·485	29·649	29·801	45·6	36·0	NE
5	29·931	30·028	29·987	29·890	44·9	30·8	NE
6	29·728	29·712	29·733	29·765	48·2	37·1	SE
7	29·622	29·599	29·638	29·776	48·9	34·2	W
8	29·878	29·998	29·990	30·017	51·2	37·1	N
9	30·025	30·057	30·006	29·967	54·9	33·0	S
10	29·899	30·048	30·184	30·256	51·1	36·5	N
11	30·223	30·150	30·000	29·916	51·1	28·3	S
12	29·790	29·749	29·700	29·706	51·2	43·0	S
13	29·688	29·703	29·675	29·680	59·6	45·3	S
14	29·583	29·604	29·775	29·949	55·0	40·8	W
15	30·058	30·163	30·183	30·257	55·1	37·0	W
16	30·206	30·095	29·999	30·069	53·7	43·1	SW
17	29·986	29·908	29·891	29·715	55·3	45·7	SW
18	29·827	29·959	30·007	30·057	56·5	42·6	NW
19	29·984	29·888	29·677	29·599	53·0	40·8	W
20	29·492	29·603	29·658	29·724	55·4	43·9	NW
21	29·725	29·702	29·778	29·886	57·8	45·6	SE
22	29·972	30·071	30·076	30·120	49·6	41·0	NE
23	30·076	30·037	29·947	29·930	49·9	39·5	ENE
24	29·877	29·881	29·847	29·839	48·8	41·0	ENE
25	29·818	29·817	29·781	29·827	53·2	40·8	E
26	29·821	29·809	29·781	29·825	61·2	40·2	ENE
27	29·841	29·906	29·889	29·951	66·9	41·8	NE
28	29·973	30·005	29·988	30·038	64·6	44·3	SW
29	30·034	30·066	29·979	29·967	61·9	47·1	SW
30	29·859	29·757	29·673	29·728	57·3	44·1	SW

GLASGOW.

1	29·227	29·235	29·309	29·460	44·6	28·4	NNE
2	29·571	29·668	29·676	29·670	40·8	29·2	SSW
3	29·615	29·560	29·474	29·498	41·3	29·6	E·E
4	29·537	29·665	29·777	29·912	42·0	32·1	ESE
5	29·982	29·994	29·883	29·814	45·3	30·0	SE
6	29·716	29·684	29·631	29·615	41·7	31·9	S
7	29·578	29·659	29·787	29·943	44·9	35·3	E
8	29·971	29·954	29·869	29·862	50·1	33·0	SE
9	29·821	29·808	29·800	29·875	47·5	39·8	W
10	29·993	30·127	30·156	30·153	51·6	36·1	W
11	30·069	29·849	29·675	29·591	46·5	35·5	S
12	29·555	29·583	29·583	29·649	53·1	42·0	S
13	29·641	29·573	29·375	29·203	51·5	43·4	SE
14	29·165	29·321	29·466	29·591	46·9	36·3	W
15	29·703	29·809	29·810	29·798	47·0	34·3	SW
16	29·669	29·583	29·692	29·714	49·1	41·0	WSW
17	29·666	29·588	29·480	29·538	49·7	38·7	SW
18	29·661	29·807	29·865	29·876	52·1	37·7	WNW
19	29·785	29·643	29·503	29·445	49·1	42·0	WSW
20	29·462	29·522	29·542	29·628	53·3	35·7	W
21	29·693	29·821	29·917	30·039	49·7	40·7	E
22	30·117	30·185	30·318	30·281	51·3	35·3	E
23	30·259	30·212	30·131	30·128	48·4	39·5	ENE
24	30·107	30·088	30·024	30·032	51·6	36·1	ENE
25	29·987	29·936	29·836	29·835	52·4	37·3	E
26	29·851	29·910	29·923	30·024	55·8	40·5	NE
27	30·004	29·994	29·937	29·929	47·8	41·0	E
28	29·998	29·952	29·933	29·948	55·1	43·3	SW
29	29·874	29·782	29·680	29·545	49·4	39·4	SW
30	29·516	29·528	29·544	29·685	50·0	39·4	W

MAY, 1897.

Date.	KEW. Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon	Date.	GLASGOW. Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·743	29·892	29·896	29·909	57·8	38·7	N	1	29·750	29·775	29·720	29·603	51·0	37·1	SW
2	29·880	29·863	29·811	29·829	59·1	39·8	SW	2	29·458	29·488	29·508	29·554	51·1	39·3	SW
3	29·832	29·875	29·891	29·994	57·2	43·3	W	3	29·594	29·659	29·716	29·865	48·0	37·8	SW
4	30·081	30·185	30·131	30·096	59·1	38·1	WNW	4	29·918	29·867	29·617	29·564	48·2	36·1	SSW
5	29·969	29·902	29·915	29·973	56·3	41·7	W	5	29·522	29·602	29·672	29·767	48·2	38·3	SW
6	30·014	30·061	30·080	30·139	52·7	38·1	WNW	6	29·837	29·917	29·946	29·968	50·4	36·6	WNW
7	30·109	30·093	30·061	30·096	55·0	39·9	W	7	29·945	29·947	29·922	29·876	48·6	36·9	E
8	30·087	30·098	30·032	30·027	63·3	47·2	SW	8	29·776	29·739	29·827	29·891	52·2	42·2	WNW
9	30·072	30·151	30·176	30·222	57·0	42·8	NW	9	29·942	30·039	30·093	30·147	52·1	40·2	WNW
10	30·174	30·067	29·879	29·783	56·2	41·0	W	10	30·069	29·936	29·811	29·903	50·9	39·0	W
11	29·831	29·885	29·873	29·963	52·3	36·4	N	11	29·873	29·892	29·947	30·024	50·1	35·2	NNW
12	30·003	30·058	30·104	30·213	48·2	34·8	N	12	30·034	30·085	30·134	30·210	49·3	37·0	N
13	30·241	30·241	30·194	30·216	51·0	33·7	NW	13	30·225	30·216	30·125	30·107	54·8	33·0	S
14	30·236	30·273	30·286	30·337	56·2	35·3	SW	14	30·071	30·093	30·150	30·220	52·8	43·8	SW
15	30·369	30·396	30·366	30·397	61·0	45·1	ESE	15	30·273	30·340	30·370	30·415	56·4	48·3	WSW
16	30·382	30·334	30·235	30·215	63·3	49·8	NE	16	30·423	30·440	30·386	30·407	65·9	44·0	ENE
17	30·128	30·089	30·005	30·071	71·1	47·8	NNE	17	30·386	30·353	30·324	30·348	64·1	44·4	E
18	30·056	30·054	30·049	30·132	72·1	45·5	NE	18	30·341	30·342	30·324	30·342	57·6	43·5	E
19	30·119	30·119	30·052	30·097	63·0	42·1	NNE	19	30·320	30·284	30·226	30·234	56·4	38·7	E
20	30·054	30·016	29·937	29·968	60·3	41·3	NNE	20	30·200	30·184	30·095	30·117	59·6	41·6	E
21	29·946	29·932	29·868	29·893	65·3	48·3	ENE	21	30·109	30·074	30·003	29·995	64·2	42·8	ENE
22	29·837	29·833	29·774	29·805	60·1	42·1	N	22	29·987	29·954	29·880	29·906	59·6	40·0	ENE
23	29·776	29·787	29·762	29·828	63·9	41·7	N	23	29·902	29·911	29·908	29·987	64·9	43·1	ESE
24	29·831	29·884	29·882	29·911	56·6	44·3	N	24	29·995	29·985	29·879	29·831	58·1	44·0	NE
25	29·872	29·791	29·668	29·646	68·9	42·9	WSW	25	29·748	29·671	29·577	29·513	55·0	44·1	W
26	29·546	29·512	29·479	29·449	57·8	48·8	SW	26	29·388	29·353	29·309	29·346	55·4	43·7	NW
27	29·385	29·348	29·315	29·357	63·2	47·7	S	27	29·347	29·365	29·364	29·362	54·7	42·3	E
28	29·341	29·315	29·360	29·425	59·0	45·2	SW	28	29·370	29·361	29·252	29·160	55·8	45·1	E
29	29·534	29·635	29·665	29·776	61·5	49·4	SSW	29	29·091	29·194	29·274	29·355	58·9	44·9	SW
30	29·721	29·826	29·811	29·824	70·8	54·0	SW	30	29·443	29·509	29·624	29·726	61·3	47·3	SW
31	29·905	29·982	29·963	29·967	70·6	50·3	S	31	29·717	29·809	29·880	29·963	64·9	48·7	S

JUNE, 1897.

1	29·896	29·815	29·844	29·965	67·1	52·9	ESE	1	30·005	30·028	29·953	29·930	58·4	48·4	E
2	30·017	30·055	30·064	30·098	64·0	48·9	W	2	29·985	30·038	30·062	30·135	60·2	50·3	E
3	30·096	30·107	30·059	30·093	67·2	51·8	NNE	3	30·154	30·195	30·177	30·169	54·8	49·0	E
4	30·077	30·079	30·032	30·071	67·4	50·7	NNE	4	30·129	30·128	30·070	30·093	66·1	46·5	E
5	30·078	30·095	30·061	30·079	71·8	55·6	N	5	30·097	30·095	30·031	30·045	75·5	54·3	W
6	30·060	30·072	30·032	30·042	75·3	55·5	SW	6	30·040	30·035	30·030	30·083	65·4	49·3	SW
7	30·041	30·073	30·086	30·108	65·0	53·3	NNE	7	30·104	30·137	30·124	30·121	50·4	45·1	ESE
8	30·058	30·009	29·905	29·781	55·2	51·8	E	8	30·082	30·027	29·925	29·898	53·8	39·3	E
9	29·652	29·682	29·769	29·905	54·0	49·0	N	9	29·832	29·842	29·845	29·938	57·3	44·8	E
10	29·975	30·101	30·168	30·254	67·1	44·6	NNE	10	29·989	30·063	30·063	30·080	62·3	45·4	W
11	30·277	30·304	30·269	30·295	74·0	47·2	SW	11	30·049	30·077	30·069	30·067	61·5	52·7	SW
12	30·296	30·287	30·236	30·236	79·0	51·1	S	12	30·084	30·112	30·110	30·121	63·8	56·6	WSW
13	30·175	30·115	30·045	29·989	81·1	58·8	SE	13	30·077	30·046	30·005	29·931	67·1	56·3	SW
14	29·936	29·976	30·036	30·144	72·1	55·1	WNW	14	29·813	29·853	29·930	30·020	61·3	52·8	WNW
15	30·191	30·197	30·096	30·031	72·7	50·9	SW	15	30·050	30·049	29·978	29·804	55·5	46·0	SW
16	29·870	29·719	29·778	29·850	62·9	48·3	WNW	16	29·410	29·354	29·525	29·602	53·3	42·2	NW
17	29·866	29·895	29·908	29·871	61·9	45·6	WNW	17	29·594	29·655	29·672	29·602	53·9	42·0	W
18	29·636	29·457	29·414	29·688	63·5	48·7	W	18	29·431	29·426	29·526	29·684	53·5	42·9	N
19	29·835	29·990	29·983	29·875	61·3	46·0	WNW	19	29·890	29·868	29·772	29·583	55·5	41·1	W
20	29·634	29·695	29·862	30·032	60·2	50·0	WNW	20	29·554	29·761	29·862	29·835	53·8	42·3	E
21	30·079	30·088	30·106	30·175	71·7	48·2	WSW	21	29·724	29·796	29·874	29·940	62·5	49·1	W
22	30·177	30·215	30·173	30·153	77·3	60·0	SW	22	29·960	29·979	29·970	30·014	65·9	51·7	SW
23	30·110	30·071	29·946	29·907	81·8	56·8	SE	23	29·990	29·968	29·928	29·910	61·8	54·8	WSW
24	29·862	29·866	29·885	29·969	84·0	56·2	SSW	24	29·889	29·966	29·981	30·017	63·4	51·8	E
25	29·998	30·028	30·027	30·045	63·3	55·1	NE	25	30·032	30·016	29·963	29·971	65·9	47·7	ESE
26	30·039	30·032	29·946	29·953	70·9	54·9	E	26	29·969	29·987	29·970	29·976	69·9	55·6	NW
27	29·905	29·876	29·825	29·878	69·7	58·8	ENE	27	29·960	29·963	29·923	29·963	67·4	54·3	E
28	29·893	29·932	29·910	29·911	75·4	59·0	SW	28	29·947	29·947	29·929	29·954	58·9	50·9	E
29	29·866	29·923	29·927	29·949	74·6	60·8	SW	29	29·923	29·911	29·882	29·899	68·3	54·5	E
30	29·967	30·001	29·959	30·000	76·2	54·4	SSW	30	29·922	29·965	29·957	30·011	71·9	56·2	ENE

JULY, 1897.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	29·989	29·986	29·983	30·040	74·7	55·1	N	1	30·008	30·024	30·017	30·073	69·9	55·2	W
2	30·085	30·126	30·114	30·066	63·6	58·1	NE	2	30·054	30·022	29·936	29·836	64·1	52·2	SW
3	30·006	29·988	29·975	30·003	70·3	55·0	WNW	3	29·759	29·706	29·709	29·710	57·9	51·0	W
4	29·995	30·027	30·054	30·108	66·0	53·2	WNW	4	29·749	29·864	29·929	29·881	57·7	49·6	WNW
5	30·067	29·972	29·850	29·793	72·6	50·3	WSW	5	29·705	29·554	29·382	29·378	61·1	50·3	SW
6	29·708	29·738	29·677	29·683	68·3	55·9	WSW	6	29·377	29·398	29·398	29·376	56·5	48·5	W
7	29·680	29·781	29·813	29·881	66·0	50·9	W	7	29·366	29·563	29·669	29·739	57·1	47·6	WNW
8	29·929	29·945	29·920	29·945	69·9	43·6	SW	8	29·743	29·781	29·662	29·560	54·1	43·8	SW
9	29·946	29·976	29·983	30·058	71·9	55·8	WSW	9	29·636	29·752	29·863	29·992	58·7	51·1	W
10	30·111	30·186	30·208	30·284	74·3	57·2	N	10	30·073	30·168	30·209	30·262	62·1	49·1	W
11	30·301	30·342	30·299	30·313	71·0	50·1	NE	11	30·273	30·301	30·267	30·265	70·5	44·7	W
12	30·277	30·268	30·174	30·182	67·1	53·1	NNE	12	30·262	30·255	30·194	30·226	75·1	50·1	NNE
13	30·131	30·081	30·028	30·032	74·0	53·8	E	13	30·239	30·223	30·151	30·144	69·1	48·8	E
14	29·979	29·930	29·876	29·906	76·1	55·4	ENE	14	30·135	30·073	30·001	30·009	69·6	51·2	E
15	29·914	29·929	29·915	29·960	78·7	53·0	N	15	29·999	29·972	29·930	29·986	81·3	48·7	W
16	29·997	30·079	30·095	30·132	76·6	55·0	N	16	30·045	30·087	30·057	30·120	76·4	50·2	NNW
17	30·104	30·080	30·065	30·062	77·0	56·6	NW	17	30·106	30·097	30·044	30·038	66·4	52·9	E
18	30·044	30·023	29·945	29·919	76·3	54·5	SSW	18	30·021	30·009	29·961	29·947	73·3	50·1	E
19	29·821	29·743	29·625	29·601	76·4	56·4	E	19	29·888	29·809	29·693	29·683	74·8	50·2	E
20	29·561	29·574	29·548	29·597	73·9	56·9	SW	20	29·641	29·640	29·621	29·665	59·0	53·3	E
21	29·620	29·674	29·711	29·781	70·5	54·4	WSW	21	29·669	29·704	29·746	29·808	63·2	52·0	NE
22	29·814	29·913	29·932	30·022	73·1	58·2	W	22	29·830	29·864	29·871	29·932	69·6	56·2	WSW
23	30·056	30·108	30·102	30·120	75·1	52·4	W	23	29·942	29·970	29·963	29·961	70·8	49·7	WSW
24	30·115	30·083	29·987	29·93·	80·1	59·2	S	24	29·965	29·938	29·841	29·714	69·0	60·2	SSW
25	29·854	29·861	29·860	29·882	73·0	60·0	WSW	25	29·582	29·596	29·561	29·539	67·0	57·0	SW
26	29·872	29·880	29·846	29·835	68·0	56·0	SW	26	29·497	29·586	29·619	29·659	63·4	53·7	WNW
27	29·809	29·843	29·908	29·986	70·0	54·8	N	27	29·675	29·721	29·782	29·832	60·8	53·1	WNW
28	29·994	30·006	30·025	30·115	68·7	56·0	W	28	29·858	29·909	29·958	29·972	62·5	52·4	W
29	30·171	30·241	30·247	30·288	73·7	57·7	W	29	30·016	30·135	30·179	30·210	67·4	54·9	WSW
30	30·293	30·295	30·226	30·228	79·4	59·0	N	30	30·213	30·251	30·255	30·257	68·1	58·1	W
31	30·173	30·156	30·084	30·088	73·9	56·9	NNE	31	30·212	30·178	30·092	30·085	72·4	55·9	ENE

AUGUST, 1897.

1	30·046	30·034	29·960	30·002	75·0	51·6	NE	1	30·069	30·057	30·011	30·023	75·1	55·3	ENE
2	30·031	30·074	30·055	30·136	80·7	53·8	NE	2	30·032	30·066	30·087	30·148	73·5	55·0	WNW
3	30·159	30·213	30·168	30·160	79·3	53·9	E	3	30·173	30·189	30·133	30·114	70·1	57·1	E
4	30·123	30·075	29·984	29·954	87·7	60·1	SE	4	30·061	30·035	29·914	29·849	77·8	55·6	SW
5	29·860	29·786	29·708	29·741	86·6	61·9	SSE	5	29·776	29·732	29·624	29·598	72·8	61·3	ESE
6	29·736	29·756	29·753	29·819	74·4	60·7	SSW	6	29·552	29·518	29·511	29·555	69·7	59·8	SW
7	29·852	29·878	29·841	29·806	74·2	59·2	SW	7	29·605	29·683	29·693	29·697	67·9	57·2	SW
8	29·715	29·558	29·493	29·579	70·1	57·9	S	8	29·637	29·602	29·589	29·627	71·0	53·2	N
9	29·676	29·784	29·817	29·886	73·3	58·1	NW	9	29·645	29·695	29·726	29·791	69·8	51·3	W
10	29·896	29·917	29·890	29·910	76·0	53·1	SW	10	29·797	29·818	29·804	29·793	65·2	50·1	SW
11	29·877	29·888	29·864	29·900	73·3	57·2	S	11	29·714	29·683	29·673	29·731	63·6	54·1	W
12	29·952	30·006	30·026	30·095	70·3	52·1	W	12	29·759	29·828	29·852	29·878	66·8	55·0	W
13	30·067	30·043	29·954	29·908	69·2	48·0	S	13	29·803	29·726	29·648	29·632	60·5	55·4	SSE
14	29·919	29·956	29·923	29·927	72·8	54·0	SW	14	29·648	29·661	29·652	29·640	62·6	51·7	SW
15	29·873	29·810	29·718	29·728	69·3	54·9	S	15	29·603	29·607	29·566	29·603	61·7	52·4	S
16	29·787	29·885	29·918	29·954	70·3	52·1	W	16	29·624	29·648	29·631	29·549	61·7	50·1	SW
17	29·830	29·783	29·730	29·750	71·5	57·6	SW	17	29·319	29·261	29·316	29·433	62·1	53·1	SW
18	29·675	29·678	29·689	29·688	71·6	55·0	SSW	18	29·471	29·547	29·572	29·612	62·8	50·4	W
19	29·677	29·782	29·799	29·855	68·5	54·3	W	19	29·598	29·614	29·590	29·540	62·1	47·2	SW
20	29·777	29·671	29·583	29·565	69·8	53·6	SSW	20	29·373	29·200	29·190	29·219	62·5	54·6	SSW
21	29·511	29·543	29·532	29·531	68·3	57·6	SW	21	29·187	29·241	29·229	29·238	59·8	51·3	SW
22	29·525	29·607	29·628	29·688	67·7	54·8	W	22	29·296	29·382	29·422	29·465	60·9	48·1	SW
23	29·705	29·744	29·749	29·752	63·8	54·1	W	23	29·512	29·551	29·555	29·563	58·1	51·8	W
24	29·658	29·613	29·585	29·602	67·3	54·0	S	24	29·539	29·575	29·588	29·674	63·8	50·1	E
25	29·586	29·644	29·680	29·741	66·1	54·2	W	25	29·680	29·707	29·684	29·683	63·5	54·2	E
26	29·744	29·740	29·666	29·609	67·6	49·6	S	26	29·636	29·573	29·462	29·484	67·4	53·2	SE
27	29·674	29·782	29·813	29·882	67·3	54·9	SW	27	29·511	29·544	29·540	29·588	64·8	47·8	SSW
28	29·889	29·917	29·891	29·928	68·2	53·5	SW	28	29·612	29·635	29·635	29·690	64·1	53·7	SSW
29	29·915	29·884	29·778	29·678	65·4	50·0	SSW	29	29·709	29·675	29·543	29·327	62·2	52·7	S
30	29·630	29·682	29·689	29·657	68·3	57·0	SW	30	29·226	29·253	29·300	29·369	60·4	53·6	S
31	29·588	29·700	29·732	29·793	64·0	50·8	SW	31	29·367	29·406	29·410	29·446	62·2	50·4	SW

SEPTEMBER, 1897.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·779	29·767	29·585	29·374	61·1	53·1	SW
2	29·403	29·495	29·555	29·676	65·1	55·2	SW
3	29·722	29·704	29·829	29·896	59·1	44·9	NW
4	29·900	29·938	29·998	30·082	57·7	42·8	W
5	30·047	29·950	29·815	29·701	63·7	46·9	SW
6	29·759	29·776	29·756	29·850	63·7	50·8	SW
7	29·908	29·976	29·970	29·949	61·9	48·6	NE
8	29·916	29·935	29·888	29·859	58·3	50·0	SW
9	29·880	29·974	30·026	30·150	58·3	45·0	NE
10	30·183	29·252	30·253	30·352	61·9	42·8	NE
11	30·354	30·382	30·356	30·411	63·1	44·0	E
12	30·415	30·445	30·421	30·465	62·3	42·3	N
13	30·464	30·490	30·443	30·469	63·2	41·7	NE
14	30·455	30·469	30·407	30·399	62·0	53·7	N
15	30·333	30·316	30·228	30·190	64·0	46·6	NW
16	30·130	30·081	29·992	29·947	62·3	53·0	NW
17	29·818	29·749	29·642	29·598	62·1	46·8	WNW
18	29·515	29·572	29·596	29·689	55·4	41·8	N
19	29·710	29·753	29·769	29·775	54·7	38·8	N
20	29·743	29·860	29·822	29·796	60·5	48·4	NW
21	29·716	29·697	29·748	29·884	66·0	48·3	W
22	29·907	29·897	29·781	29·738	57·9	48·2	SW
23	29·741	29·808	29·780	29·851	65·3	52·2	SW
24	29·857	29·896	29·879	29·924	65·1	58·4	SW
25	30·060	30·184	30·154	30·153	66·1	51·3	SSW
26	30·101	30·114	30·097	30·184	66·9	52·1	SW
27	30·205	30·265	30·201	30·196	63·1	45·4	W
28	30·109	30·089	30·040	30·042	62·6	52·1	ESE
29	29·984	29·936	29·813	29·733	68·3	52·0	S
30	29·713	29·742	29·720	29·792	60·9	50·1	SW

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·459	29·466	29·389	29·293	61·4	54·3	W
2	29·241	29·370	29·467	29·396	57·1	49·4	NNW
3	29·666	29·728	29·767	29·695	51·4	42·9	WNW
4	29·653	29·725	29·775	29·843	59·0	40·0	WNW
5	29·747	29·752	29·745	29·714	54·8	44·9	NW
6	29·516	29·561	29·645	29·840	59·1	48·2	W
7	29·925	29·973	29·934	29·968	55·4	44·0	WNW
8	29·906	29·913	29·889	29·929	56·4	40·2	E
9	29·998	30·096	30·142	30·242	55·5	41·3	NE
10	30·288	30·341	30·332	30·384	52·8	39·1	WNW
11	30·363	30·399	30·344	30·366	53·4	38·8	W
12	30·362	30·396	30·449	30·460	57·5	47·3	WSW
13	30·465	30·488	30·471	30·478	57·4	55·5	WSW
14	30·457	30·445	30·385	30·350	61·1	54·3	W
15	30·275	30·228	30·112	30·109	57·3	49·9	WSW
16	30·036	29·946	29·791	29·626	57·8	47·4	WSW
17	29·518	29·534	29·493	29·595	53·5	44·4	W
18	29·647	29·661	29·642	29·712	54·8	39·2	NW
19	29·737	29·817	29·826	29·877	57·4	38·5	W
20	29·846	29·823	29·724	29·622	57·8	42·5	WNW
21	29·466	29·562	29·633	29·679	55·8	48·8	NW
22	29·647	29·541	29·457	29·481	52·2	48·2	SW
23	29·479	29·350	29·263	29·337	57·4	47·1	SW
24	29·395	29·389	29·489	29·619	56·1	46·4	WNW
25	29·757	29·775	29·865	29·846	57·0	46·2	WSW
26	29·784	29·746	29·845	29·962	57·0	49·1	WSW
27	30·044	30·112	30·098	30·089	59·1	47·1	WSW
28	30·024	29·980	29·892	29·852	61·9	48·6	SSW
29	29·760	29·719	29·644	29·634	57·8	50·9	WSW
30	29·635	29·727	29·751	29·830	60·3	46·5	NW

OCTOBER, 1897.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·857	29·971	30·032	30·112	60·2	49·6	N
2	30·142	30·197	30·159	30·177	60·1	49·3	WSW
3	30·107	30·177	30·209	30·274	59·8	48·6	NW
4	30·277	30·336	30·349	30·407	54·3	46·1	N
5	30·406	30·407	30·377	30·408	55·3	39·7	E
6	30·406	30·439	30·403	30·428	51·9	43·3	ESE
7	30·407	30·421	30·351	30·354	53·2	39·0	W
8	30·290	30·245	30·132	30·089	54·8	34·0	SW
9	30·094	30·158	30·177	30·217	54·7	46·2	WNW
10	30·196	30·175	30·096	30·036	54·3	47·0	SW
11	29·942	29·943	29·876	29·911	56·6	44·3	W
12	29·923	29·967	29·933	29·920	52·3	39·6	W
13	29·849	29·827	29·811	29·836	50·9	36·6	W
14	29·755	29·703	29·602	29·583	61·0	43·6	SSE
15	29·508	29·476	29·446	29·430	62·4	52·9	S
16	29·447	29·663	29·806	29·926	63·3	54·2	SSW
17	29·948	29·995	29·972	29·966	65·2	55·9	S
18	29·996	30·117	30·142	30·196	63·2	52·5	SW
19	30·182	30·193	30·231	30·347	64·3	47·3	E
20	30·412	30·496	30·474	30·515	59·9	42·6	NW
21	30·521	30·565	30·525	30·532	56·0	39·3	NE
22	30·463	30·444	30·364	30·320	53·7	46·3	NE
23	30·237	30·217	30·146	30·184	55·2	49·9	ENE
24	30·178	30·220	30·173	30·200	54·9	46·2	E
25	30·185	30·195	30·151	30·193	54·7	40·2	E
26	30·225	30·289	30·291	30·320	57·5	40·1	E
27	30·295	30·292	30·249	30·260	56·1	41·1	E
28	30·234	30·245	30·182	30·166	53·2	39·4	E
29	30·128	30·119	30·062	30·095	63·5	35·2	SE
30	30·080	30·140	30·127	30·192	62·1	40·0	SSE
31	30·199	30·250	30·237	30·307	55·6	42·1	E

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon
1	29·888	29·982	30·034	30·079	56·1	40·1	E
2	30·075	30·077	30·027	30·026	56·0	47·1	S
3	30·063	30·132	30·185	30·288	56·4	45·8	NW
4	30·230	30·264	30·309	30·367	53·7	38·3	SW
5	30·312	30·272	30·207	30·291	55·2	43·1	SSW
6	30·261	30·295	30·265	30·259	55·3	39·4	WNW
7	30·197	30·205	30·124	30·067	53·9	43·5	WSW
8	29·939	29·868	29·887	29·960	53·1	46·1	NW
9	29·990	30·048	30·027	29·979	52·4	43·8	NW
10	29·865	29·726	29·657	29·654	55·7	46·5	W
11	29·674	29·740	29·775	29·847	51·4	42·9	NW
12	29·872	29·870	29·813	29·818	47·4	36·8	WNW
13	29·763	29·756	29·734	29·744	45·3	33·5	W
14	29·712	29·695	29·592	29·579	42·5	28·2	E
15	29·472	29·248	29·172	29·258	55·1	36·3	ESE
16	29·172	29·224	29·428	29·482	54·3	40·3	SW
17	29·491	29·444	29·457	29·499	60·6	54·2	SSW
18	29·500	29·760	29·873	29·932	57·1	52·1	WSW
19	29·989	30·081	30·178	30·274	54·6	48·3	W
20	30·324	30·402	30·420	30·466	58·1	46·3	WSW
21	30·478	30·521	30·488	30·522	58·8	39·1	NE
22	30·516	30·505	30·433	30·421	57·5	40·6	NE
23	30·360	30·324	30·254	30·284	50·4	42·8	E
24	30·296	30·315	30·297	30·298	51·1	40·3	E
25	30·267	30·260	30·193	30·183	56·3	43·5	E
26	30·176	30·218	30·214	30·268	50·6	37·4	N
27	30·251	30·203	30·140	30·142	52·9	41·8	E
28	30·127	30·130	30·091	30·099	52·4	44·8	NE
29	30·025	30·011	29·937	29·935	50·3	42·4	ENE
30	29·937	29·998	30·057	30·178	51·8	47·1	ENE
31	30·237	30·313	30·311	30·313	53·3	44·9	E

NOVEMBER, 1897.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·317	30·349	30·302	30·307	55·3	42·0	E	1	30·308	30·358	30·342	30·378	51·7	45·1	ESE
2	30·275	30·285	30·238	30·253	49·8	44·0	E	2	30·366	30·365	30·326	30·314	47·6	44·0	E
3	30·221	30·227	30·168	30·195	49·7	44·0	NE	3	30·306	30·307	30·262	30·294	47·4	43·1	E
4	30·174	30·191	30·171	30·223	44·3	42·1	NE	4	30·284	30·270	30·230	30·249	46·9	43·1	ESE
5	30·237	30·307	30·304	30·339	43·7	40·7	NE	5	30·260	30·317	30·326	30·389	45·8	43·4	N
6	30·328	30·334	30·265	30·240	49·4	41·1	NE	6	30·401	30·420	30·371	30·341	48·8	44·1	ENE
7	30·200	30·161	30·080	30·084	48·9	40·2	NNE	7	30·301	30·296	30·204	30·109	48·9	43·6	E
8	30·073	30·138	30·172	30·242	54·3	46·8	E	8	30·043	30·076	30·108	30·184	53·3	46·4	E
9	30·261	30·284	30·255	30·246	54·4	50·0	E	9	30·212	30·256	30·247	30·249	52·1	46·2	E
10	30·205	30·232	30·169	30·178	51·0	34·5	ESE	10	30·191	30·166	30·104	30·102	52·1	47·0	E
11	30·172	30·197	30·152	30·138	42·2	33·6	W	11	30·073	30·066	29·960	29·843	54·5	50·2	SW
12	30·032	29·969	29·867	29·789	55·9	41·6	SW	12	29·622	29·421	29·314	29·279	56·4	50·3	SW
13	29·865	29·674	29·646	29·645	58·7	52·6	WSW	13	29·194	29·293	29·366	29·443	55·7	48·3	W
14	29·578	29·583	29·563	29·603	58·6	48·9	S	14	29·441	29·460	29·622	29·674	49·1	36·1	NE
15	29·762	30·025	30·193	30·337	51·0	36·3	N	15	30·006	30·150	30·250	30·332	38·5	30·9	NE
16	30·362	30·369	30·264	30·189	47·9	37·6	SSW	16	30·266	30·155	29·968	29·829	45·8	30·1	SSW
17	30·124	30·130	30·079	30·075	55·2	48·0	SW	17	29·720	29·752	29·742	29·767	53·0	45·8	SW
18	30·073	30·140	30·219	30·360	57·4	36·0	W	18	29·828	29·938	30·009	30·073	50·2	45·8	W
19	30·398	30·475	30·448	30·513	47·6	33·7	SW	19	30·085	30·117	30·131	30·289	54·3	47·4	W~W
20	30·552	30·647	30·631	30·667	50·1	36·9	SW	20	30·370	30·493	30·528	30·551	53·2	50·7	WSW
21	30·668	30·708	30·672	30·685	51·9	36·9	SW	21	30·534	30·539	30·515	30·530	51·4	48·1	SW
22	30·666	30·664	30·580	30·570	48·0	35·2	SW	22	30·544	30·544	30·464	30·455	49·8	43·9	WSW
23	30·487	30·489	30·422	30·435	43·9	38·3	NNE	23	30·409	30·402	30·383	30·439	52·6	42·6	W
24	30·406	30·403	30·328	30·260	43·9	36·2	NNE	24	30·399	30·359	30·258	30·175	44·0	39·9	ENE
25	30·188	30·232	30·329	30·453	48·0	38·1	E	25	30·175	30·301	30·364	30·333	43·9	42·1	E
26	30·500	30·501	30·366	30·279	45·0	28·6	S	26	30·174	30·082	30·048	29·985	47·9	43·1	W
27	30·155	30·057	29·931	29·876	52·4	45·0	WSW	27	29·838	29·700	29·712	29·648	48·2	40·1	WNW
28	29·787	29·657	29·233	29·199	50·1	40·8	SW	28	29·436	29·020	28·847	28·889	44·3	36·3	WNW
29	29·131	29·442	29·731	29·896	43·7	32·3	N	29	29·333	29·627	29·719	29·636	41·2	34·6	W
30	29·844	29·662	29·415	29·337	52·0	31·6	WSW	30	29·295	29·271	29·163	29·187	45·8	35·9	NNW

DECEMBER, 1897.

1	29·369	29·461	29·508	29·691	45·1	36·0	W	1	29·243	29·436	29·701	29·955	39·1	32·3	E
2	29·844	30·021	30·139	30·220	41·1	34·0	N	2	30·106	30·241	30·302	30·331	41·7	32·8	NW
3	30·241	30·270	30·215	30·199	41·3	28·0	N	3	30·273	30·197	30·052	29·919	40·9	31·3	SSW
4	30·172	30·191	30·162	30·192	36·3	25·3	N	4	29·867	29·983	29·991	30·008	43·1	39·6	ESE
5	30·183	30·211	30·163	30·129	39·8	35·8	SE	5	29·957	29·931	29·843	29·799	46·8	38·6	SE
6	30·032	29·985	29·942	29·962	45·2	37·1	SSW	6	29·711	29·641	29·514	29·668	46·5	37·9	SSW
7	30·113	30·090	29·860	29·952	52·1	36·1	SW	7	29·682	29·401	29·111	28·993	50·4	37·8	SW
8	29·358	29·407	29·355	29·342	53·8	37·7	WSW	8	28·939	28·896	28·744	28·705	41·5	33·1	WSW
9	29·317	29·378	29·417	29·526	44·8	36·5	W	9	28·792	28·918	29·060	29·192	44·1	38·7	WNW
10	29·561	29·445	29·005	28·998	48·0	34·9	S	10	29·240	29·128	28·892	28·902	41·1	37·9	SE
11	29·103	29·407	29·611	29·731	47·6	36·1	WNW	11	29·061	29·215	29·360	29·472	41·5	36·7	WSW
12	29·764	29·660	29·578	29·755	38·9	31·3	E	12	29·506	29·538	29·511	29·525	38·4	35·1	WSW
13	29·740	29·614	29·539	29·485	52·4	29·1	S	13	29·411	29·275	29·252	29·084	44·3	32·3	SW
14	29·409	29·449	29·496	29·418	53·1	44·4	SW	14	29·074	29·179	29·214	29·188	49·1	38·2	S
15	29·388	29·599	29·779	29·836	50·7	44·1	WSW	15	29·078	29·164	29·382	29·536	45·5	39·7	WNW
16	29·773	29·845	29·897	29·982	55·1	49·3	S	16	29·438	29·346	29·364	29·488	52·9	41·0	SW
17	30·046	30·143	30·164	30·249	54·0	39·9	SW	17	29·612	29·773	29·876	29·994	51·9	47·9	SW
18	30·262	30·315	30·292	30·317	44·5	39·0	W	18	30·074	30·188	30·250	30·322	48·0	36·4	WNW
19	30·314	30·318	30·297	30·299	45·7	39·8	E	19	30·338	30·382	30·366	30·378	38·1	27·5	E
20	30·299	30·342	30·344	30·397	43·2	38·5	E	20	30·378	30·418	30·435	30·466	40·3	30·2	E
21	30·429	30·501	30·525	30·592	39·1	35·4	E	21	30·495	30·549	30·552	30·575	40·3	33·3	E
22	30·596	30·626	30·592	30·591	39·7	25·7	ESE	22	30·574	30·572	30·519	30·504	33·6	25·1	NW
23	30·559	30·555	30·514	30·505	30·1	25·2	E	23	30·454	30·444	30·394	30·357	28·5	25·4	NW
24	30·434	30·410	30·334	30·336	32·9	22·8	E	24	30·282	30·254	30·140	30·136	37·7	27·5	E
25	30·335	30·352	30·333	30·399	29·6	21·8	E	25	30·090	30·088	30·075	30·119	46·4	35·9	SW
26	30·383	30·395	30·272	30·182	45·3	21·8	E	26	30·053	29·908	29·669	29·582	51·1	42·8	SW
27	30·097	30·038	29·922	29·868	48·4	45·0	SSW	27	29·496	29·416	29·320	29·392	51·8	43·6	E
28	29·876	29·883	29·821	29·888	49·7	42·8	SW	28	29·422	29·404	29·328	29·378	45·8	38·6	WSW
29	29·800	29·656	29·559	29·470	52·7	44·0	SSW	29	29·253	28·921	28·963	28·915	50·4	39·4	SW
30	30·256	30·260	30·285	30·278	49·7	44·8	SSW	30	28·637	28·635	28·778	28·807	51·7	40·9	SW
31	30·245	30·276	30·268	30·294	47·3	42·6	SW	31	28·680	28·792	28·870	28·996	44·3	39·9	SW

Diagram shes and the Direction of Explosions

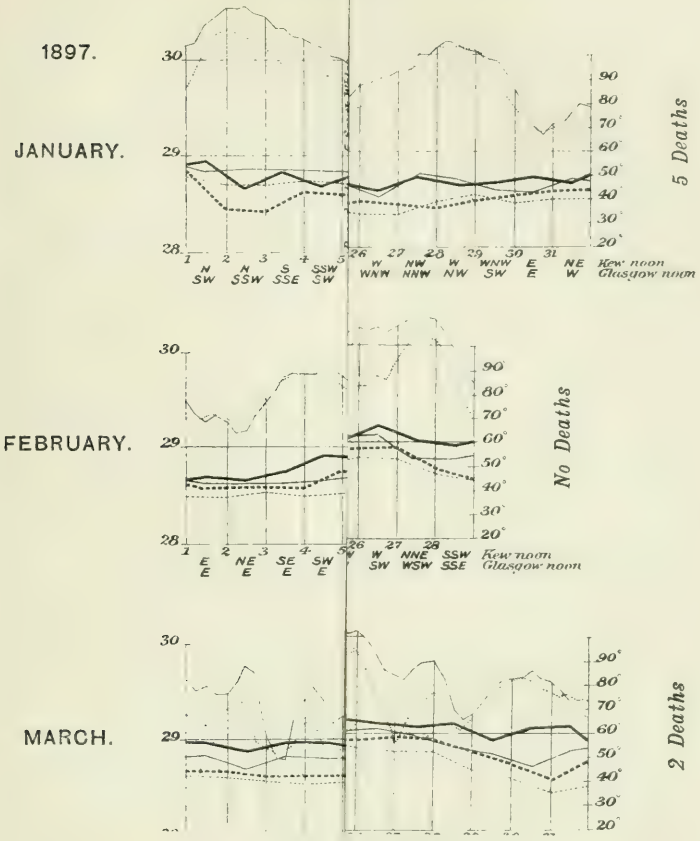
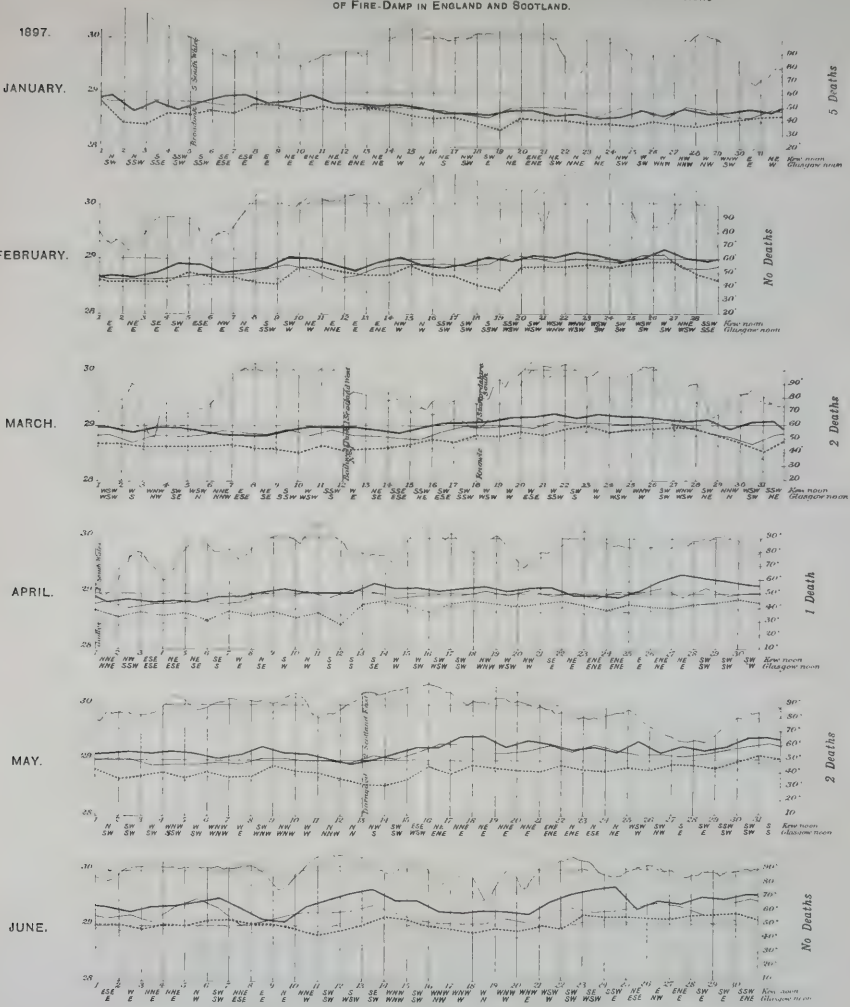


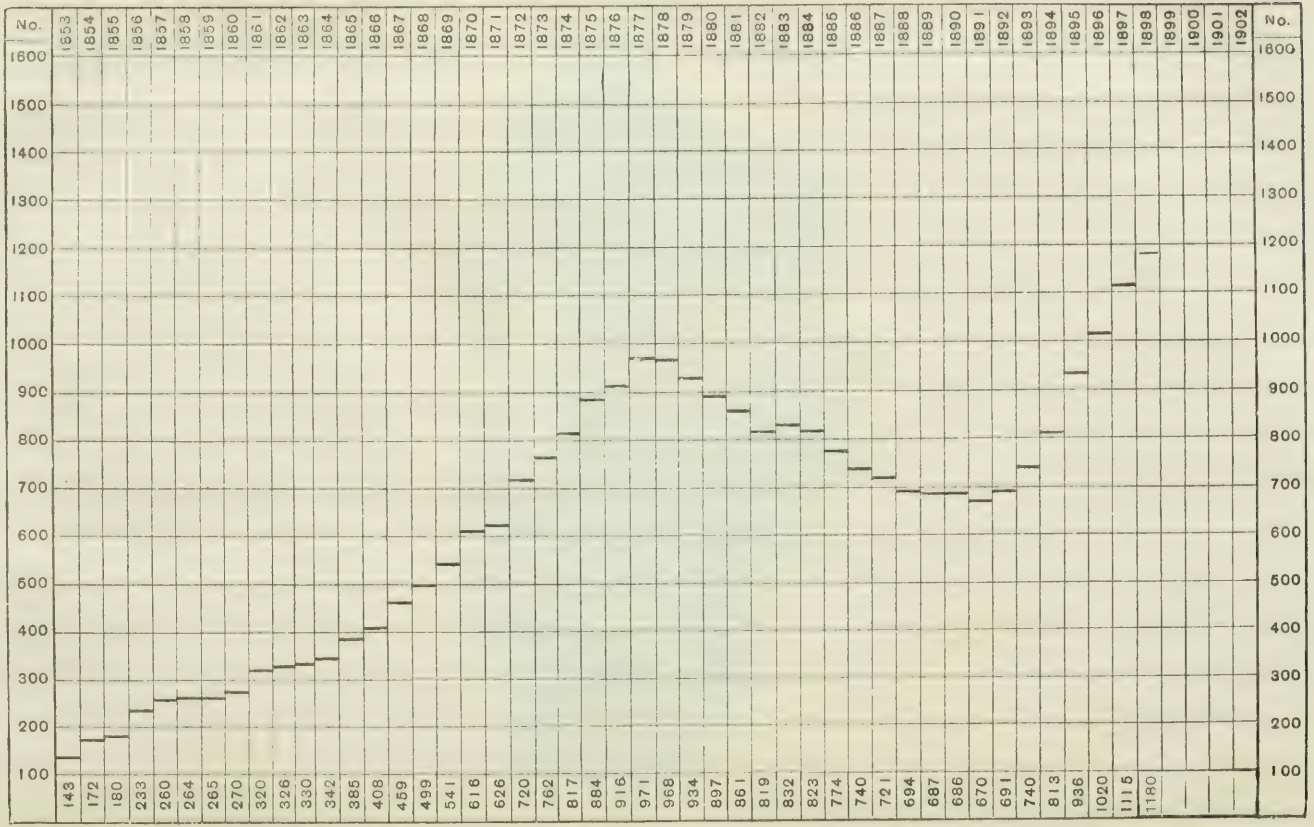
Diagram shewing the Height of the Barometer, the Maxima and Minima Temperatures and the Direction of the Wind at the Observatories of Kew and Glasgow, together with the Explosions of Fire-Damp in England and Scotland.



The firm top line is the Barometer reading at Kew, taken at 4 a.m., 10 a.m., 4 p.m., and 10 p.m.
The dotted top line is the Barometer reading at Glasgow, taken at 4 a.m., 10 a.m., 4 p.m., and 10 p.m.
The lower lines are the Maxima and Minima Temperatures at Kew and Glasgow, observed respectively at midnight and 9 p.m
Kew lines are thick and Glasgow lines are thin.
The figures attached to the districts shew the Number of Deaths caused by the Explosions.

Wood Memorial Hall, and Offices of the North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

DIAGRAM EXHIBITING MEMBERSHIP SINCE ITS FOUNDATION IN 1852.



PRESENTED BY THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS

THE NORTH OF ENGLAND INSTITUTE

OF

Mining and Mechanical Engineers.

ANNUAL REPORT OF THE COUNCIL

AND

ACCOUNTS FOR THE YEAR 1897-98;

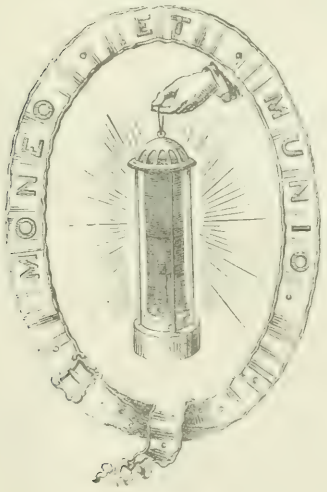
LIST OF

COUNCIL, OFFICERS, AND MEMBERS,

FOR THE YEAR 1898-99;

THE CHARTER AND BYE-LAWS; Etc.

1897-98.



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1898.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL, 1897-98.

The following table shows the number of members of the various classes during a few recent years:—

	August 1st.		
	1896.	1897.	1898.
Honorary Members...	23	29	30
Members	767	829	859
Associate Members	78	98	115
Associates	83	91	103
Students	46	45	51
Subscribers	23	23	22
Totals	1,020	1,115	1,180

The Council are pleased to report a continued expansion of the membership as recorded in the preceding table, and urge the members to endeavour, at all times, to extend it. The class of Associates, comprizing persons employed in subordinate positions in mines, has proved successful, and has materially assisted in increasing the roll of members.

The members have to regret the deaths of Mr. Thomas John Bewick, Mr. Stephen Campbell Crone, and Mr. William Lishman (Sunderland), who had for many years been actively connected with the Institute, and had served on the Council.

With the view of rendering the Wood Memorial Hall more useful to the members, the Council have had plans prepared for lighting from the roof, extension of the book-shelving, erection of entrance-porch, furnishing, warming, decoration, etc., at an estimated cost of about £2,000. The work is now in progress, and it is hoped that the alterations will be completed on September 1st next ensuing.

With the view of reducing the expenses of the Institute, the Council have agreed to let Room No. 4, now held under lease, to the Coal Trade Associations, at a rental of £75 per annum, for a term of 7 years, from November 11th, 1897.

A portrait of the late Sir George Elliot has been presented by his grandson, Sir George Elliot. The Council trust that the series of portraits of Past-Presidents may be completed by gift or bequest, and that succeeding Presidents will each in rotation assist in maintaining the completion of this collection.

The meetings of Students and Associates have been continued, and one paper has been printed in the *Transactions*.

The revision of the composition, payable in lieu of the annual subscription, has been approved, as shown by the number of members who have so compounded. The Council will invest the amounts so received, as suitable investments are suggested to them.

The additions to the Library by donation, exchange, and purchase have been :—

Bound volumes	286
Pamphlets, reports, etc.	246
A total of	532 titles.

and the Library now contains about 7,739 volumes and 1,750 unbound pamphlets. The Card Catalogue renders the books readily available for reference. The Library (including the books and weekly engineering papers) is available to members residing in the vicinity, from 10 a.m. to 5 p.m. daily, and those residing at a distance may make use of the books by communication with the Secretary. Some of the files of publications have been rendered incomplete by the neglect of members to return borrowed books, and it is earnestly requested that members will return the missing volumes.

The Library would be rendered more valuable if members would present volumes, etc., which they can spare from their own libraries. Members would also render valuable service to the profession by bequeathing books, reports, plans, etc., to the Library, where they would be available for reference, and maintain the memory of the donor.

By arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne, whose premises are connected with the Library of the Institute, members of either institution are permitted (on producing a member's pass) to refer to the books in the Library of either institution.

The publication of the *Sinkings and Borings* has been completed, and the series of six volumes may be purchased from the Secretary. Members are desired to send copies of any unpublished sections of strata in Durham or Northumberland, or their section-books on loan, to the Secretary, with the view of their being published in a supplementary volume.

The prices of the *Transactions* and other publications of the Institute have been reduced, and members are recommended to complete their sets before the stock is exhausted (volumes iii. to vi. are now out of print).

A General Index to volumes i. to xxxviii. of the *Transactions* of the Institute is in preparation, and the Council trust that it will be received with approval by the members.

The Council suggest that Indian and Colonial members should arrange local meetings for the reading and discussion of papers, and trust that success will attend such efforts.

The report of the Committee on Mechanical Ventilators is approaching completion, and will be issued during the current year to the members.

Mr. John Herman Merivale has been appointed to represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science at Bristol in September next. Messrs. James McMurtrie and W. B. Harrison will represent the Institute at the meeting of the Sanitary Institute to be held in Birmingham in September next. Mr. John Daglish acts on behalf of the Institute as a governor of the Durham College of Science, Newcastle-upon-Tyne. Mr. W. Cochrane is the Institute representative on the Science and Art Committee ; and Mr. Henry Ayton, on the Scholarships Committee of the Northumberland County Council.

The Federated Institution of Mining Engineers has now become The Institution of Mining Engineers, and the Council urge the members, who may be interested in other societies, to use their influence in favour of federation, by which the success of the Institution will be completely assured.

The Institution of Mining Engineers has now completed its ninth year, during which General Meetings have been held in Edinburgh, on September 14th, 15th, and 16th, 1897: in Newcastle-upon-Tyne, on February 22nd, 23rd, and 24th, 1898: and in London, on May 19th, 20th, and 21st, 1898. A meeting of students, associates, and junior members was held in Newcastle-upon-Tyne, on August 18th, 19th, and 20th, 1897. The meetings held in this district were well attended, and the thanks of the Institute are due to the Committees who made the arrangements, and to all of those who, by their services, contributed to the holding of these successful meetings.

The President's (Mr. George May) students' prize was awarded to Mr. G. P. Chaplin, for his paper on "Cornish Methods of Mine-timbering."

Prizes of books have been awarded the writers of the following papers, communicated to the members during the year 1896-7 :—

"The Gold-fields of the Hauraki Peninsula, New Zealand." By the Rev. Joseph Campbell.
"Cornish Methods of Mine-timbering." By Mr. G. P. Chaplin.
"The Mineral Resources of the Colony of Queensland." By Mr. William Fryar.
"Notes on the Coal-seams of the Transvaal, and Description of a Modern Pit-head Plant." By Mr. W. T. Hallimond.
"Notes upon Foreign Mining Laws and Adequate Areas for Mining Concessions." By Mr. H. D. Hoskold.
"The Education of Metallurgists." By Mr. Saville Shaw.
"Notes on the Sinking of Two Shafts at Claravale Colliery." By Mr. F. R. Simpson.

The papers communicated during the year comprize :—

"Pyritic Smelting." By Mr. Wm. Lawrence Austin.
"Experiments with the Shaw Gas-tester." By Dr. P. P. Bedson and Mr. J. Cooper, B.Sc.
"Memoir of the late Mr. Thomas John Bewick, M. Inst. C E., F.G.S." By Mr. T. B. Bewick.
"Notes on Rearer Workings." By Mr. John Cadman.
"Secondary Haulage: Cost of Putting and Driving." By Messrs. T. E. Forster and F. R. Simpson.
"Notes on the Geology of Finland." By Principal H. Palin Gurney.
"Notes on the Iron Industry in the Urals." By Prof. H. Louis.
"Presidential Address." By Mr. George May.
"Occurrences and Mining of Manjak in Barbados, West Indies." By Mr. Walter Merivale.
"The Siliceous Iron-ores of Northern Norway." By Mr. H. T. Newbigin.
"The Gold-regions of Alabama, U.S.A." By Mr. Wm. B. Phillips.
"Hydrothermal Gold-deposits at Peak Hill, Western Australia." By Mr. Frank Reed, Inspector of Mines.
"A Method of dealing with Running-sand when met with in Borings." By Mr. Geo. B. Reynolds.

The members may be congratulated upon the number and varied nature of the papers printed in the *Transactions*, and the Council trust that similar contributions will be forwarded as liberally as heretofore.

In conclusion, the Council desire to impress upon the members that the success of the Institute in the future is dependent upon an increase in the membership, so as to meet the increased expences incurred by its connexion with The Institution of Mining Engineers.

REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts from August 1st, 1897, to June 30th, 1898, covering a period of only eleven months. This is in consequence of the Council having decided that the books shall in future be closed on June 30th in each year, in order to allow greater time for the preparation and audit of the accounts than was possible when they were closed on July 31st and submitted to the annual meeting at the beginning of August. Owing to this change, a proper comparison with the accounts of the previous year cannot be instituted.

The total income during the period named was £2,749 9s. 6d. Of this amount, £113 was paid as life-compositions in lieu of annual subscriptions, and £89 11s 10d. was received from the South Wales Institute of Engineers and The Institution of Mining Engineers, in repayment of moneys previously expended by this Institute in connexion with the Fan Committee's Report, leaving £2,546 17s. 8d. as the ordinary income.

The names of several members whose subscriptions were in arrear have been struck off the list of members, and the amounts written off in consequence are for the current year £48 6s. 0d., and arrears £67 4s. 0d.

The total expenditure amounted to £1,883 16s. 0d., and the sum of £950 has been placed on deposit with the bankers.

During the month of July, additional subscriptions have been received amounting to £114 9s. 0d., and payments have been made of £284 11s. 6d., including £200 on account of the alterations to the Wood Memorial Hall, so that the balance of capital at July 31st was £9,278 12s. 11d., as compared with £8,769 13s. 1d. at July 31st, 1897.

GEORGE MAY.

August 6th, 1898.

General Statement, June 30th, 1898.

Liabilities.

	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	73	10	0			
„ carried over from previous year	2	2	0			
				75	12	0
The Institution of Mining Engineers				96	2	9
Capital				9,448	15	5
				£9,620	10	2

We have examined the above accounts with the books, vouchers, and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the "Transactions and other Publications" as valued by your Officials.

JOHN G. BENSON AND SON,
Chartered Accountants.

Newcastle-upon-Tyne,
August 5th, 1898.

Assets.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	674	2	5			
„ in Treasurer's hands	66	17	0			
Outstanding amounts due for Authors' Excerpts	2	5	3			
				743	4	8
Arrears of Subscriptions				393	15	0
146 Shares in the Institute and Coal Trade Chambers Co., Ltd. (at cost)	3,130	0	0			
Investment with the Institute and Coal Trade Chambers Co., Ltd. (Mortgage)	1,400	0	0			
				4,530	0	0
Interest on ditto, half-year				24	10	0
(Of the above amount, £350 is due to Life Subscriptions Account, leaving £323 12s. not invested.)						
Deposit with Lambton & Co.				1,150	0	0
Value of Transactions and other Publications, as per Stock Account				579	0	6
Office Furniture and Fittings	450	0	0			
Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£9,620	10	2

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

July 31st, 1897.	£	s.	d.	£	s.	d.
To Balance at Bankers	725	10	6			
„ .. in Treasurer's hands	100	0	0			
„ Outstanding Amounts due for Authors' Excerpts £5 7 5						
Less—Written off 3 6 9						
	2	0	8			
July 31st, 1898.				827	11	2
To Dividend of 7½ per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for year ending June, 1898	219	0	0			
„ Interest on Mortgage of £1,400 with Institute and Coal Trade Chambers Company, Ltd.	24	10	0			
				243	10	0
.. South Wales Institute of Engineers, proportion of Fan Committee Expenses	34	6	8			
„ The Institution of Mining Engineers, repayment of do.	55	5	2			
				89	11	10
„ Sales of Transactions				52	3	8
TO SUBSCRIPTIONS FOR 1897-98 AS FOLLOWS:—						
690 Members ... ... @ £2 2s.	1,449	0	0			
69 Associate Members ... ... @ £2 2s.	144	18	0			
79 Associates ... ... @ £1 1s.	82	19	0			
35 Students ... ... @ £1 1s.	36	15	0			
75 New Members ... ... @ £2 2s.	157	10	0			
30 New Associate Members ... ... @ £2 2s.	63	0	0			
15 New Associates ... ... @ £1 1s.	15	15	0			
11 New Students ... ... @ £1 1s.	11	11	0			
	1,961	8	0			
TO SUBSCRIBING FIRMS, VIZ.:— £ s. d.						
1 @ £4 4s. 4 4 0						
1 @ £2 2s. 2 2 0						
	6	6	0			
TO NEW SUBSCRIBING FIRMS, VIZ.:—						
2 @ £4 4s.	8	8	0			
	1,976	2	0			
TO LIFE COMPOSITIONS:—						
2 Members £41 0 0						
1 New Member 24 0 0						
2 New Associate Members 48 0 0						
	113	0	0			
	2,089	2	0			
Less—Subscriptions for current year paid in advance at the end of last year...	49	7	0			
	2,039	15	0			
Add—Arrears received	250	19	0			
	2.290	14	0			
Add—Subscriptions paid in advance during current year	73	10	0			
				2,364	4	0
				£3,577	0	8

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.
JULY 31ST, 1898.

June 30th, 1898.	£	s.	d.	£	s.	d.
By Printing and Stationery				151	6	6
„ Books for Library	30	11	9			
„ Prizes for Papers	11	11	0			
„ Incidental Expenses	49	14	7			
„ Postages	60	10	10			
„ Sundry Accounts	7	0	0			
„ Travelling Expenses	0	6	0			
„ Salaries	125	0	0			
„ Clerks' Wages	207	3	2			
„ Reporting	17	17	0			
„ Rent	58	17	2			
„ Rates and Taxes	20	3	5			
„ Insurance	8	6	11			
„ Furnishing and Repairs	7	7	3			
„ Coals, Gas, Water, and Electric Light	44	14	7			
„ Expenses of Meetings	20	14	5			
„ Explosives Committee, Rent	0	5	0			
„ General Index	17	16	6			
				687	19	7
By The Institution of Mining Engineers—						
Subscriptions	1,050	15	5			
Less—Amounts paid by Authors for Excerpts ...	6	5	6			
				1,044	9	11
				1,883	16	0
By Investments—						
Lambton & Co. Deposit Account				950	0	0
				2,833	16	0
By Balance at Bankers	674	2	5			
„ „ in Treasurer's hands	66	17	0			
Outstanding Amounts due for Authors' Excerpts ..	2	5	3			
				743	4	8
				£3,577	0	8

We have examined the above account with the books and vouchers relating thereto, and certify that, in our opinion, it is correct.

JOHN G. BENSON AND SON.
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 5th, 1898.

DR. THE TREASURER IN ACCOUNT

		£ s. d.	£ s. d.
To 829 Members.			
1 ,, not on printed list.			
830			
2 ,, paid Life Composition			41 0 0
828			
37 of whom are Life Members.			
791	@ £2 2s.		1,661 2 0
To 98 Associate Members.			
7 of whom are Life Members.			
91	@ £2 2s.		191 2 0
To 91 Associates	@ £1 1s.		95 11 0
To 45 Students			
1 Elected Associated Member			
44	@ £1 1s.		46 4 0
To 23 Subscribing Firms			90 6 0
To 75 New Members	@ £2 2s.		157 10 0
To 1 New Member, paid Life Composition			24 0 0
To 2 New Associate Members, paid Life Composition ..			48 0 0
To 30 New Associate Members @ £2 2s.			63 0 0
To 15 New Associates	@ £1 1s.		15 15 0
To 11 New Students	@ £1 1s.		11 11 0
To 2 New Subscribing Firms			8 8 0
			2,453 9 0
To Arrears, as per Balance Sheet 1896-97		346 10 0	
Add—Arrears considered irrecoverable, but since paid ...		49 7 0	
		395 17 0	
Less—Struck off as irrecoverable—Arrears	£67 4 0		
,, ,, ,, Current year	48 6 0		
		115 10 0	
			280 7 0
			2,733 16 0
To Subscriptions Paid in Advance			73 10 0
			£2,807 6 0

WITH SUBSCRIPTIONS, 1897–98. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 690 Members, paid	@ £2 2s.	1,449 0 0	.....
By 96 „ unpaid	@ £2 2s.	.....	201 12 0
By 5 „ dead	@ £2 2s.	.....	10 10 0
791			
By 69 Associate Members, paid	@ £2 2s.	144 18 0	.....
By 22 „ „ unpaid	@ £2 2s.	.....	46 4 0
91			
By 79 Associates, paid	@ £1 1s.	82 19 0	.....
By 12 „ unpaid	@ £1 1s.	.....	12 12 0
91			
By 35 Students, paid	@ £1 1s.	36 15 0	.....
By 9 „ unpaid	@ £1 1s.	.....	9 9 0
44			
By 2 Subscribing Firms, paid		6 6 0	.....
By 21 „ unpaid		.....	84 0 0
23			
By 75 New Members, paid	@ £2 2s.	157 10 0	.....
By 2 Members, paid Life Composition		41 0 0	.....
By 1 New Member, paid Life Composition		24 0 0	.....
By 30 New Associate Members, paid ...	@ £2 2s.	63 0 0	.....
By 2 New Associate Members, paid Life Composition ...		48 0 0	.....
By 15 New Associates, paid	@ £1 1s.	15 15 0	.....
By 11 New Students, paid	@ £1 1s.	11 11 0	.....
By 2 New Subscribing Firms, paid		8 8 0	.....
		2,089 2 0	364 7 0
Less—Struck off as irrecoverable		.....	48 6 0
			316 1 0
By Arrears		250 19 0	77 14 0
By Subscriptions paid in advance		73 10 0	.....
		2,413 11 0	393 15 0
			2,413 11 0
			£2,807 6 0

OFFICERS, 1898-99.

PRESIDENT.

Mr. WILLIAM ARMSTRONG, Wingate, Co. Durham.

VICE-PRESIDENTS.

Mr. T. W. BENSON, 24, Grey Street, Newcastle-upon-Tyne.
Mr. THOMAS FORSTER BROWN, Guildhall Chambers, Cardiff.
Mr. J. L. HEDLEY, 2, Devonshire Terrace, Newcastle-upon-Tyne.
Sir WILLIAM THOMAS LEWIS, Bart., Mardy, Aberdare.
Mr. R. ROBINSON, Howlish Hall. near Bishop Auckland.
Mr. J. G. WEEKS, Bedlington, R.S.O., Northumberland.

COUNCIL.

Mr. HENRY AYTON, 122, Rye Hill, Newcastle-upon-Tyne.
Mr. W. C. BLACKETT, Acorn Close, Sacriston, Durham.
Mr. BENJAMIN DODD, Bearpark Colliery, near Durham.
Mr. THOMAS E. FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. WILLIAM F. HALL, Haswell Colliery, Haswell, *via* Sunderland.
Mr. THOMAS E. JOBLING, Bebside, Northumberland.
Mr. A. C. KAYLL, Gosforth, Newcastle-upon-Tyne.
Mr. H. LAWRENCE, 24, Grainger Street West, Newcastle-upon-Tyne.
Mr. WILLIAM LOGAN, Langley Park Colliery, Durham.
Prof. HENRY LOUIS, 11, Summerhill Terrace, Newcastle-upon-Tyne.
Mr. C. W. MARTIN, Newbottle Colliery Offices, Fence Houses.
Mr. J. H. MERIVALE, Togston Hall, Acklington, Northumberland.
Mr. HENRY PALMER, Medomsley, R.S.O., Co. Durham.
Mr. A. M. POTTER, Beaconfield, Corbridge-upon-Tyne.
Mr. J. A. RAMSAY, Sherburn and Littletown Collieries, near Durham.
Mr. T. O. ROBSON, Chowdene Cottage, Low Fell, Gateshead-upon-Tyne.
Mr. F. R. SIMPSON, Hedgefield House, Blaydon-upon-Tyne.
Mr. J. SIMPSON, Heworth Colliery, Felling, R.S.O., Co. Durham.

Ex-Officio.

Lord ARMSTRONG, C.B., LL.D., D.C.L., F.R.S., Cragside, Rothbury.
Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.
Mr. G. B. FORSTER. Farnley Hill, Corbridge-upon-Tyne.
Mr. JOHN DAGLISH, Rothley Lake, Cambo, R.S.O., Northumberland.
Sir LOWTHIAN BELL, Bart., D.C.L., F.R.S., Rounton Grange, Northallerton.
Mr. W. COCHRANE, St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne.
Mr. J. B. SIMPSON, Bradley Hall, Wylam-upon-Tyne.
Mr. A. L. STEAVENSON, Durham.
Mr. T. DOUGLAS, The Garth, Darlington.
Mr. GEORGE MAY, The Harton Collieries, South Shields.

Past-Presidents.

Retiring Vice-Presidents.

Mr. C. BERKLEY, Marley Hill, Swalwell, R.S.O., Co. Durham.
Mr. W. O. WOOD, South Hetton, Sunderland.

TREASURER.

Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne

SECRETARY.

Mr. M. WALTON BROWN, Neville Hall, Newcastle-upon-Tyne.

LIST OF MEMBERS,

AUGUST 6, 1898.

PATRONS.

His Grace the DUKE OF NORTHUMBERLAND.
The Most Noble the MARQUIS OF LONDONDERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq.
BARON BARNARD.

HONORARY MEMBERS.

* Honorary Members (during term of Fellowship).

	Date of Election
1 The Right Honourable the EARL of RAVENSWORTH, Ravensworth Castle, Gateshead-upon-Tyne	Nov. 3, 1877
2*J. B. ATKINSON, H.M. Inspector of Mines, 10, Foremount Terrace, Glasgow	Aug. 4, 1888
3*W. N. ATKINSON, H.M. Inspector of Mines, Barlaston, Stoke-upon-Trent	Aug. 4, 1888
4*R. DONALD BAIN, H.M. Inspector of Mines, Springwell Hall, Durham	Dec. 12, 1896
5*W. BEATTIE-SCOTT, H.M. Inspector of Mines, Park Avenue, Handsworth, near Birmingham	Dec. 10, 1887
6*Prof. P. PHILLIPS BEDSON, Durham College of Science, Newcastle-upon-Tyne	Feb. 10, 1883
7 THOMAS BELL, 15, The Valley, Scarborough	Dec. 12, 1896
8*Prof. G. S. BRADY, Durham College of Science, Newcastle-upon-Tyne	Nov. 6, 1875
9 Dr. BRASSERT, Bonn-on-the-Rhine, Germany	Dec. 8, 1883
10 JOSEPH DICKINSON, South Bank, Sandy Lane, Pendleton, Manchester	Dec. 13, 1852
11*C. LE NEVE FOSTER, H.M. Inspector of Mines, Llandudno	Aug. 4, 1888
12 Prof. WILLIAM GARNETT, 3, Foley Avenue, Well Walk, Hampstead Heath, London, N.W.	Nov. 24, 1894
13 Sir ARCHIBALD GEIKIE, Director-General of the Geological Survey of the United Kingdom, 28, Jermyn Street, London, S.W.	June 11, 1898
14*JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester	June 11, 1892
15*Rev. H. PALIN GURNEY, Principal, Durham College of Science, Roseworth, Gosforth, Newcastle-upon-Tyne	Jan. 19, 1895
16*HENRY HALL, H.M. Inspector of Mines, Rainhill, Lancashire	March 4, 1876
17*J. L. HEDLEY, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne	April 9, 1892
18 WILLIAM HENRY HEDLEY, 34, Beverley Terrace, Cullercoats	Dec. 12, 1896
19*Prof. A. S. HERSCHEL, Observatory House, Slough, Bucks	Aug. 3, 1872
20*Prof. G. A. LEBOUR, Durham College of Science, Newcastle-upon-Tyne	Nov. 1, 1879
21*Prof. HENRY LOUIS, Durham College of Science, Newcastle-upon-Tyne. *Transactions* to be sent to The Secretary, Durham College of Science, Newcastle-upon-Tyne	Dec. 12, 1896

	Date of Election.
22*J. S. MARTIN, H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Bristol	Aug. 4, 1888
23 Sir CHARLES MARK PALMER, Bart., Grinkle Park, Loftus, R.S.O., Yorkshire. *Transactions* to be sent to The Mechanics' Institute, Felling-upon-Tyne	Feb. 12, 1898
24*JOSEPH T. ROBSON, H.M. Inspector of Mines, Ravensworth, Eaton Grove, Swansea	Aug. 4, 1888
25*J. M. RONALDSON, H.M. Inspector of Mines, 44, Athole Gardens, Glasgow	Aug. 4, 1888
26*A. H. STOKES, H.M. Inspector of Mines, Greenhill, Derby ...	Aug. 4, 1888
27*Prof. H. STROUD, Durham College of Science, Newcastle-upon-Tyne	Nov. 5, 1892
28 M. E. VUILLEMIN, Mines d'Aniche, Nord, France	Sept. 7, 1878
29*FRANK N. WARDELL, H.M Inspector of Mines, Wath-upon-Dearne, near Rotherham	Feb. 4, 1865
30*Prof. ROBERT LUNAN WEIGHTON, Durham College of Science, Newcastle-upon-Tyne	April 2, 1898

MEMBERS.

Marked * have paid life composition.

	Date of Election and of Transfer.
1 Abraham, David, Pencoedcae, Merthyr Tydvil	June 8, 1895
2 Aburrow, Charles, P.O. Box 534, Johannesburg, Transvaal	Feb. 13, 1892
3 Ackroyd, William, The Wheatleys, Birkenshaw, near Leeds	Feb. 7, 1880
4 Adams, Henry Hopper, Waihi, New Zealand	April 10, 1897
5 Adamson, Thomas, Kurhurbaree Colliery, E.I.R., Bengal, India	Feb. 10, 1894
6 Agassiz, Alexander, Museum of Comparative Zoology, Cambridge, Massachussets, U.S.A.	Feb. 9, 1895
7 Ainsworth, J. W., Bridgewater Trustees Colliery, Walkden, Bolton, Lancashire	Dec. 14, 1895
8 Aitkin, Henry, Falkirk, N.B....	March 2, 1865
9 Alexander, William Edward Cayley, Thermo-Hyperphoric Ore Treating Syndicate, Limited, 168 and 169, Dashwood House, New Broad Street, London, E.C. ...	Oct. 9, 1897
10 Allan, John F., Apartado de Correo, No. 121, Mexico, D.F.	A.M. Feb. 10, 1883
	M. June 8, 1889
11 Allan, T. Alexander, c/o Gibbs, Bright and Company, Melbourne, Australia	Feb. 11, 1893
12 Allchurch, Enrique, Calle Las Heras, 273, Buenos Aires, Argentine Republic	June 8, 1895
13 Allison, J. J. C., Woodland Collieries, Butterknowle, R.S.O., Co. Durham	A.M. Feb. 13, 1886 M. June 8, 1889
14 Andersen, Carl, P.O. Box 120, Denver, Colorado, U.S.A.	Oct. 12, 1895
15 Anderson, C. W., Cleadon Park, Sunderland	Aug. 21, 1852
16 Anderson, R. Hay, Apartado Postal 866, Mexico, D.F. ...	Aug. 4, 1894
17 Anderson, R. S., Benwell View, Bentinck Road, Newcastle-upon-Tyne	S. June 9, 1883 A.M. Aug. 4, 1888 M. Aug. 3, 1889
18 Andrews, Charles Fitz-Hugh, Isaac's Harbour, Guysborough County, Nova Scotia	Feb. 13, 1897
19 Angus, James, Ochiltree House, Ochiltree, Ayrshire, N.B.	Oct. 8, 1892
20*Angwin, B., P.O. Box 2050, Johannesburg, Transvaal ...	Nov. 24, 1894
21 Appleby, W. R., 911, Fifth Street, S.E., Minneapolis, Minnesota, U.S.A.	April 14, 1894
22 Archer, Oakeley, 156, Hereford Street, Christchurch, New Zealand	June 13, 1896
23 Archer, T., 11, Regent Terrace, Gateshead-upon-Tyne ...	July 2, 1872
24 Archer, William, Victoria Garesfield, Lintz Green ...	A. Aug. 6, 1892 M. Aug. 3, 1895
25 Argall, Philip, P.O. Box 1095, Denver, Colorado, U.S.A.	June 21, 1894
26 Armstrong, Lord, C.B., LL.D., D.C.L., F.R.S., Cragside, Rothbury (Past-President, *Member of Council*) ...	May 3, 1866

		Date of Election and of Transfer.	
27	Armstrong, Henry, Chester-le-Street	A.M.	April 14, 1883
		M.	June 8, 1889
28	Armstrong, William, Wingate, Co. Durham (President, *Member of Council*)	S.	April 7, 1867
		M.	Aug. 6, 1870
29	Ashcroft, Edgar Arthur, 13, Victoria Street, Westminster, London, S.W.		Aug. 3, 1895
30	Ashcroft, Harry, Borrea Coal Company, Limited, Seetarampore, Bengal, India		Aug. 4, 1894
31	Ashmore, G. Percy, c/o G. Harris Ganteaume Agent, Caratal (New) Mines, Limited, Cuidad Bolivar, Venezuela, South America, *via* Trinidad		Feb. 13, 1897
32	Ashworth, John, 5, King Street, Manchester		April 25, 1896
33	Asquith, T. W., Harperley Hall, Tantobie, R.S.O., Co. Durham		Feb. 2, 1867
34	Atherton, James, 13, Mawdsley Street, Bolton		Aug. 1, 1896
35	Atkinson, Claude W., Glendale, Woodland Place, Penarth, South Wales		Aug. 6, 1892
36	Atkinson, L. B., 10, Westbourne Road, Penarth, South Wales		Aug. 6, 1892
37	Atkinson, R. H. M. Buddle, Riding Mill-upon-Tyne ...		April 10, 1897
38	Aubrey, R. C.		Feb. 5, 1870
39	Austin, W. Lawrence, P.O. Box 941, Denver, Colorado, U.S.A.		June 21, 1894
40	Ayton, Ernest F., El Bote Mining Negociacion, Zacatecas, Republic of Mexico		Aug. 1, 1891
41	Ayton, Henry, 122, Rye Hill, Newcastle-upon-Tyne (*Member of Council*)	S.	March 6, 1875
		A.M.	Aug. 2, 1884
		M.	June 8, 1889
42	Backhouse, Frank Herbert, Coolgardie, Western Australia		June 13, 1896
43	Bailes, E. T., Wingate, Ferryhill	A.M.	June 7, 1879
		M.	June 8, 1889
44	Bailes, T., Jesmond Gardens, Newcastle-upon-Tyne ...		Oct. 7, 1858
45	Bailey, Edward Trenholm, Mining Engineer, Sandakan, British North Borneo	A.M.	June 13, 1896
		M.	June 12, 1897
46	Bailey, Samuel, 30, Waterloo Street, Birmingham ...		June 2, 1859
47	Bain, R. Donald, H.M. Inspector of Mines, Springwell Hall, Durham	S.	March 1, 1873
		M.	Aug. 5, 1876
48	Bainbridge, E., 4, Whitehall Court, London, S.W. ...	S.	Dec. 3, 1863
		M.	Aug. 1, 1868
49	Ballard, Robert, Menzies, Western Australia		April 10, 1897
50	Banks, Thomas, 60, King Street, Manchester. *Transactions* to be sent to 17, Park Avenue, Eccles, near Manchester		Aug. 4, 1877
51	Barker, M. W., 110, Stapleton Hall Road, Stroud Green, London, N.		April 8, 1893
52	Barnard, Robert, Gangootia Colliery, Desherghur P.O., Barakar, Bengal, India		Dec. 11, 1897
53	Barrett, C. R., Whitehill Hall, Chester-le-Street	S.	Nov. 7, 1874
		A.M.	Aug. 7, 1880
		M.	Dec. 11, 1886
54*	Bartholomew, C. W., Blakesley Hall, near Towcester ...		Dec. 4, 1897
55	Bates, Sidney, Mickley Colliery Offices, Stocksfield-upon-Tyne	A.	Feb. 8, 1890
		M.	June 8, 1895
56	Bates, Thomas, The Grange, Prudhoe-upon-Tyne		Feb. 9, 1895
57	Batey, John, Newbury Collieries, Coleford, Bath		Dec. 5, 1868
58	Baumgartner, W. O., Whitburn, near Sunderland ...	S.	Sept. 6, 1879
		M.	Aug. 5, 1882
59	Bawden, James Barnet, c/o Hannan's Star Gold Mines, Kalgoorlie, Western Australia		Dec. 11, 1897
60	Bayldon, Daniel Henry, New Zealand Mines Trust, Limited, Mutual Life Buildings, Martin Place, Sydney, New South Wales		Feb. 8, 1890
61	Beanlands, Arthur, Palace Green, Durham		March 7, 1867
62	Becher, Septimus J., Geological Survey Office, Perth, Western Australia		Feb. 13, 1897

		Date of Election and of Transfer.
63	Bell, Sir Lowthian, Bart., D.C.L., F.R.S., Rounton Grange, Northallerton (Past-President, *Member of Council*) ...	July 6, 1854
64	Bell, George Fred., H.M. Inspector of Mines, 20, Wentworth Place, Newcastle-upon-Tyne	S. Sept. 6, 1879 A.M. Aug. 6, 1887 M. Aug. 3, 1889
65	Bell, Walter, c/o Pyman, Bell and Company, Hull ...	S. Oct. 8, 1889 M. Feb. 10, 1894
66	Bellingham, George, Bayley Street, Coolgardie, Western Australia	Nov. 24, 1894
67	Bennett. Alfred H., Dean Lane Collieries, Bedminster, Bristol	A.M. April 10, 1886 M. June 8, 1889
68	Benson, J. G., 12, Grey Street, Newcastle-upon-Tyne ...	Nov. 7, 1874
69	Benson, T. W., 24, Grey Street, Newcastle-upon-Tyne (Vice-President, *Member of Council*)	Aug. 2, 1866
70	Berkley, C., Marley Hill, Swalwell, R.S.O., Co. Durham (Retiring Vice-President, *Member of Council*) ...	Aug. 21, 1852
71	Berkley, Frederick, Hamsterley Colliery, Ebchester, R.S.O., Co. Durham...	A.M. Dec. 9, 1882 M. June 8, 1889
72	Berkley, R. W., Marley Hill, Swalwell, R.S.O., Co. Durham	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
73	Beynon, J C. S., P.O. Box 1364, Johannesburg, Transvaal	June 10, 1893
74	Bibby, William, Raub Australian Gold Mining Company, Limited, Raub, Pahang, Malay Peninsula	Jan. 19, 1895
75	Bigg-Wither, Harris, 10, Swinley Road, Wigan, Lancashire	Jan. 19, 1895
76	Bigland, J., Henknowle, Bishop Auckland	June 3, 1857
77	Bilgrami, Syed Ali Shamsul Ulama, Director-General of Mines, Hyderabad, Deccan, India	April 11, 1891
78	Bishop, James, Grey Valley Coal Company, Brunnerton, Greymouth, New Zealand	April 13, 1889
79	Black, W., Lovaine House, Lovaine Place, Newcastle-upon-Tyne	April 2, 1870
80	Blackburn, William Stevenson, Aire Villas, Astley, Woodlesford, near Leeds	Dec. 10, 1887
81	Blackett, W. C., Acorn Close, Sacriston, Durham (*Member of Council*)	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
82	Blakemore, W., Glace Bay, Cape Breton, Canada	Oct. 12, 1895
83	Bolam, Philip, North Walbottle Colliery, Newcastle-upon-Tyne	A. Dec. 12, 1891 M. Aug. 3, 1895
84	Bolton, Edgar Ormerod, Executor of Colonel Hargreaves, Colliery Offices, Burnley	April 12, 1890
85	Bolton, H. H., Newchurch Collieries, near Manchester ...	Dec. 5, 1868
86	Borlase, W. H., Brown How, Ulleswater, Glenridding, near Penrith	Aug. 4, 1894
87	Boucher, A. S., Kempsey House, near Worcester	Aug. 4, 1883
88	Bowman, Andrew H., McClure Coke Company, Scottdale, Westmoreland County, Pennsylvania, U.S.A.	Oct. 9, 1897
89	Bradford, George, Newton House, Darlington	Oct. 11, 1890
90	Bramwell, Hugh, Great Western Colliery, near Pontypridd, Glamorganshire	S. Oct. 4, 1879 A.M. Aug. 6, 1887 M. Aug. 3, 1889
91	Breakell, John E., The Transito Company, Limited, Transito Mine, Ibagué, Tolima, Republic of Colombia, South America. *Transactions* to be sent to Brassington-by-Wirksworth, Derbyshire	April 25, 1896
92	Breakell, Thomas, Brassington, near Derby	Feb. 11, 1893
93	Breckon, J. R., 53, John Street, Sunderland	Sept. 3, 1864
94	Brierley, Brandon Talfourd, Bellayre, Lymm, Cheshire	June 13, 1896
95	Britten, T. J., P.O. Box 494, Johannesburg, Transvaal	June 21, 1894
96	Broja, Geheimer Bergrath Richard, 77, Kaiser-Wilhelm-strasse, Breslau, Germany	Nov. 6, 1880
97	Bromly, A. H., 18, Eldon Street, London, E.C.	Nov. 24, 1894
98	Broome, George Herbert, The Westport Cardiff Coal Company, Limited, Seddonville, *via* Westport, New Zealand	Oct. 9, 1897

		Date of Election and of Transfer.
99*	Brough, Bennett H., 28, Victoria Street, London, S.W. ...	A.M. Dec. 10, 1887
		M. June 8, 1889
100	Brough, Thomas, New Seaham Colliery, Sunderland ...	S. Feb. 1, 1873
		A.M. Aug. 2, 1879
		M. June 8, 1889
101	Brown, Archibald T., 372, Flinders Lane, Melbourne, Australia	Aug. 5, 1893
102	Brown, Myles, Nirshachetty P.O., Shampore, *via* Barakar, E.I.R., Bengal, India	April 10, 1897
103	Brown, M. Walton, 10, Lambton Road, Newcastle-upon-Tyne (Secretary, *Member of Council*)	S. Oct. 7, 1871
		M. Aug. 3, 1878
104	Brown, Robert, Equitable Coal Company, Limited, Desherghur, *via* Barakar, E.I.R., Bengal, India ...	April 10, 1897
105	Brown, Thomas, District Manager, Westport Coal Company, Millerton, Westport, New Zealand	April 13, 1889
106	Brown, Thomas Forster, Guildhall Chambers, Cardiff (Vice-President, *Member of Council*)	Aug. 1, 1861
107	Brown, Westgarth Forster, Fairview, Dynas Powis, near Cardiff	S. Aug. 6, 1887
		M. Aug. 5, 1893
108	Bruce, John, Port Mulgrave, Hinderwell, R.S.O., Yorkshire	S. Feb. 14, 1874
		A.M. Aug. 7, 1880
		M. June 8, 1889
109	Bryham, W., Douglas Bank Collieries, Wigan	Aug. 3, 1865
110	Buglass, J., Stobswood, *via* Acklington, Northumberland	A. Dec. 10, 1892
		M. Aug. 3, 1895
111	Bulkley, F. Groendycke, Denver, Colorado, U.S.A. ...	Oct 12, 1895
112	Bulman, E. H., North Randfontein Gold Mining Company, Limited, Mine Office, Krugersdorp, South African Republic	Feb. 13, 1892
113	Bulman, H. F., Rosville, Richmond Hill Avenue, Clifton, Bristol	S. May 2, 1874
		A.M. Aug. 6, 1881
		M. June 8, 1889
114	Bunkell, Henry B., P.O. Box 1463, Johannesburg, Transvaal	April 8, 1893
115	Bunning, C. Z., c/o The Borax Company, Limited, 2, Macri Khan, Constantinople	S. Dec. 6, 1873
		A.M. Aug. 5, 1882
		M. Oct. 8, 1887
116*	Burls, Herbert T.	Feb. 9, 1889
117*	Burn, Frank H., 22, Windsor Terrace, Newcastle-upon-Tyne	S. Feb. 9, 1889
		A. Aug. 4, 1894
		M. Aug. 3, 1895
118	Burnett, Cuthbert, Grange Iron Works, Durham ...	June 8, 1895
119*	Burns, David, Scotland Road, Stanwix, Carlisle	May 5, 1877
120	Burrows, J. S., Green Hall, Atherton, near Manchester ...	S. Oct. 11, 1873
		M. Aug. 4, 1877
121	Butt, Thomas Philip Edward, Aktien-Gesellschaft Elektricitätswerke, Langenthal, Bern, Switzerland ...	Dec. 11, 1897
122	Butters, Charles, 20, Bishopsgate Street Within, London, E.C.	Feb. 10, 1894
123	Cameron, Ian, Keeler, California, U.S.A.	Aug. 4, 1894
124	Campbell, H. H., Sutton Hall, St. Helens, Lancashire ...	Jan. 19, 1895
125	Campbell, The Rev. Joseph, Te Aroha, New Zealand ...	A.M. Dec. 12, 1896
		M. Feb. 13, 1897
126	Campbell, W. Young, P.O. Box 357, Johannesburg, Transvaal	April 8, 1893
127	Campbell-Johnston, R. C., Nelson, British Columbia ...	Nov. 24, 1894
128*	Candler, T. E., East Lodge, Crook, Co. Durham	S. May 1, 1875
		A.M. Aug. 4, 1883
		M. June 8, 1889
129	Carnes, Charles Spearman, Cornwall House, Murton Colliery, Sunderland	Aug. 1, 1891
130	Carr, T., Lilywhite Terrace, Four Lane Ends, Hetton-le-Hole, R.S.O., Co. Durham	Feb. 10, 1894

		Date of Election and of Transfer.
131	CHALMERS, J. A., c/o J. S. Sheldrick, 96, Gresham House, Old Broad Street, London, E.C.	Dec. 9, 1893
132	CHAMBERS, J. S., Little Italianskaja No. 5, St. Petersburg, Russia	Oct. 10, 1896
133	CHANDLEY, CHARLES, P.O. Box 221, Coolgardie, Western Australia	S. Nov. 6, 1880 A. Aug. 3, 1889 M. Dec. 12, 1896
134	CHANNING, J. PARKE, 34, Park Place, New York City, U.S.A.	April 25, 1896
135	CHAPMAN, H. R., Victoria Works, Gateshead-upon-Tyne ...	Nov. 24, 1894
136	CHARLETON, A. G., 5, Avonmore Road, Kensington, London, W.	Aug. 6, 1892
137	CHARLTON, WILLIAM, Guisbrough, Yorkshire	Feb. 12, 1898
138	CHARLTON, WILLIAM, Linares, Provincia de Jaen, Spain ...	April 8, 1893
139	CHARLTON, WILLIAM JOHN, Ashington Colliery, Morpeth, Northumberland	April 25, 1896
140	CHATER, JOSEPH, Bengal Nagpur Coal Company, Limited, Evelyn Lodge, Kumarpur, Asansol, Bengal, India ...	Dec. 9, 1893
141	CHEESMAN, E. TAYLOR. Claravale Colliery, Ryton-upon-Tyne	A. Aug. 2, 1890 M. Aug. 6. 1892
142	CHEESMAN, HERBERT, Hartlepool	Aug. 6, 1892
143	CHEESMAN, I. T., Throckley Colliery, Newcastle-upon-Tyne	Feb. 1, 1873
144	CHEESMAN, W. T., 4, Bridgford Road, Nottingham... ...	Feb. 5, 1876
145	CHILDE, HENRY S., Mining Engineer, Wakefield	A.M. Feb 12, 1887 M. Aug. 3, 1889
146	CLARK, C. F., Garswood Coal and Iron Company, Limited, near Wigan	Aug. 2, 1866
147	CLARK, ROBERT, Hyderabad Deccan Company, Limited, Secunderabad, India...	Feb. 15, 1896
148	CLARK, R. B., Springwell Colliery, Gateshead-upon-Tyne ...	S. May 3, 1873 M. Aug. 4, 1877
149	CLAUDET, ARTHUR C., 6 and 7, Coleman Street, London, E.C.	Aug. 3, 1895
150	CLIFFORD, WILLIAM, Pittsburg, Pennsylvania, U.S.A. ...	Feb. 9, 1895
151	CLOUGH, JAMES. Bomarsund House, Bomarsund, Bedlington, R.S.O., Northumberland	S. April 5, 1873 A.M. Aug. 3, 1878 M. June 8, 1889
152	COCHRANE, B., Aldin Grange, Durham	Dec. 6, 1866
153	COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne (PAST-PRESIDENT, *Member of Council*)	Aug. 1, 1861
154	COCKSON, CHARLES, Wingates, Hayes, Middlesex	A.M. April 22, 1882 M. Aug. 3, 1889
155	COGHLAN, F. M., Catorce, S.L.P., Mexico	Dec. 9, 1893
156	COLLINS, ARTHUR LAUNCELOT, 14 and 15, Broad Street Avenue, London, E.C.	Feb. 13, 1892
157*	COLLINS, HORATIO, General Manager, Modderfontein Extensions, Limited, P.O. Box 735, Johannesburg, Transvaal	Aug. 4, 1894
158*	COLLINS, H. B., 121, West George Street, Glasgow... ...	April 14, 1894
159	COLQUHOUN, T. GRANT, General Manager, Cassell Coal Company, Limited, Springs, South African Republic ...	Dec. 14, 1889
160	COMMANS, R. E., 6, Queen Street Place, London, E.C. ...	Nov. 24, 1894
161	COMSTOCK, THEO. B., Prescott Development Syndicate, Limited, 535, Stimson Block, Los Angeles, California, U.S.A.	Feb. 13, 1897
162	COOK, J., Washington Iron Works, Washington, Co. Durham	May 8, 1869
163	COOK, JOSEPH, Jun., Washington Iron Works, Washington, Co. Durham	Oct. 9, 1897
164	COOK, J. WATSON, Teesdale House, Princes Street, Bishop Auckland	Oct. 14, 1893
165	COOKE, GERVASE, No. 1, The Bund, Shanghai, China ...	June 11, 1898
166	COOKE, HENRY MOORE ANNESLEY, Pestarena United Gold Mining Company, Limited, Pestarena, Vall Anzasca, Novara, Italy	Dec. 12, 1896
167	CORBETT, V. W., Chilton Moor, Fence Houses	Sept. 3, 1870

		Date of Election and of Transfer.
168	CORBITT, M., Springfield, Durham Road, Gateshead-upon-Tyne	Dec. 4, 1875
169	CORBOULD, W. H., P.O. Box 796, Rossland, British Columbia, *via* New York	June 8, 1895
170	CORK, F. LAWRENCE	Dec. 9, 1893
171	CORLETT, GEORGE STEPHEN, Wigan	Dec. 12, 1891
172	COULSON, F., 10, Victoria Terrace, Durham	S. Aug. 1, 1868 M. Aug. 2, 1873
173	COULTHARD, FRANCIS, Arica Villa, Whitehaven	June 8, 1889
174	COX, JOHN H., 10, St. George's Square, Sunderland ...	Feb. 6, 1875
175	CRAVEN, HIRAM, Jun., Mechanical Engineer, Sunderland ...	April 12, 1890
176	CRAZE, JAMES MAYNE, Coolgardie, Western Australia ...	Aug. 7, 1897
177	CRIGHTON, JOHN, Union Iron Works, Stewart Street, Stockport	June 11, 1898
178	CRONE, E. W., Killingworth, near Newcastle-upon-Tyne ...	S. March 5, 1870 M. Aug. 5, 1876
179	CRONE, J. R., Tudhoe House, *via* Spennymoor	Feb. 1, 1868
180	CROOKSTON, ANDREW WHITE, 188, St. Vincent Street, Glasgow	Dec. 14, 1895
181	CROSS, JOHN, 77, King Street, Manchester	June 5, 1869
182	CROUDACE, C. J., Bettisfield Colliery Company, Limited, Bagillt, North Wales	Nov. 2, 1872
183	CROUDACE, FRANK, The Scottish Australian Mining Company, Limited, Lambton, Newcastle, New South Wales	Aug. 3, 1895
184	CROUDACE, T., West House, Haltwhistle	Dec. 9, 1893
185	CROUDACE, THOMAS, Lambton Lodge, Lambton, Newcastle, New South Wales	Nov. 6, 1862
186	CURRIE, WALTER, P.O. Box 220, Buluwayo, Rhodesia, South Africa	April 25, 1896
187	DAGLISH, JOHN, Rothley Lake, Cambo, R.S.O., Northumberland (PAST-PRESIDENT, *Member of Council*)	Aug. 21, 1852
188	DAGLISH, WILLIAM CHARLTON, Littleburn Colliery, near Durham	Dec. 12, 1896
189	DAKERS, W. R., The Loggins, Tudhoe Colliery, *via* Spennymoor, Durham	A.M. Oct. 14, 1882 M. Aug. 3, 1889
190	DALE, SIR DAVID, Bart., West Lodge, Darlington	Feb. 5, 1870
191	DAN, TAKUMA, c/o Mitsui Mining Company, No. 4, Surugacho, Nihonbashi-Ku, Tokio, Japan	April 14, 1894
192	DANIEL, PETER FRANCIS, Greymouth, New Zealand ...	April 8, 1893
193	DARBY, J. H., Pen y Garth, Brymbo, Denbighshire	Feb. 9, 1895
194	DARLING, FENWICK, South Durham Colliery, Darlington ...	Nov. 6, 1875
195	DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales	S. Nov. 7, 1874 M. Aug. 4, 1877
196	DAVEY, GEORGE, Waitekauri Gold Mining Company, Waitekauri, Auckland, New Zealand	June 10, 1893
197	DAVEY, HENRY, 3, Princes Street, Westminster, London, S.W.	Oct. 11, 1873
198	DAVIES, JOHN, Hartley House, Coundon, Bishop Auckland...	April 10, 1886
199	DAVIES, J. HUBERT, P.O. Box 455, Johannesburg, Transvaal	April 8, 1893
200	DAVIS, KENNETH, Dudley Colliery, Northumberland ...	April 13, 1889
201	DAVISON, J. FORD, Yarlside, Dalton-in-Furness	Oct. 13, 1894
202	DAW, ALBERT WILLIAM, 11, Queen Victoria Street, London, E.C.	June 12, 1897
203	DAW, JOHN, Jun., Brooklands, Rosemont Road, Acton, London, W.	Dec. 14, 1895
204	DEES, J. GIBSON, Floraville, Whitehaven	Oct. 13, 1883
205	DEES, R. R., Newcastle-upon-Tyne	Oct. 7, 1871
206	DELPRAT, G. D., The Broken Hill Proprietary Company, Limited, Broken Hill, New South Wales	Feb. 10, 1894
207	DENNY, G. A., No. 3, Grusonwerk, Marshall Square, Johannesburg, Transvaal	Dec. 8, 1894
208	DEWHURST, JOHN HUBERT, Grove House, Walton-le-Dale, Preston, Lancashire	April 2, 1898
209	DICKINSON, ARTHUR, Warham Road, South Croydon, Surrey	April 14, 1894

Date of Election and of Transfer.

210 Diest, Edmond C. van, San Luis, Costilla County, Colorado, U.S.A. ... ... July 14, 1896
211 Dixon, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea Nov. 2, 1872
212* Dixon, James S., Fairleigh, Bothwell, N.B. ... ... Aug. 3, 1878
213 Dixon, Jonathan, Manager, Greta Collieries, New South Wales ... ... Oct. 13, 1894
214 Dixon, R., Sankey Wire Mills and Ropeworks, Warrington June 5, 1875
215 Dixon, William, Cleator, Cumberland ... ... April 10, 1897
216 Dobb, T. G., Moorland House, Aspull, near Wigan, Lancashire ... ... Dec. 8, 1894
217 Dobbs, Joseph, Jarrow Colliery, Castlecomer, Co. Kilkenny April 14, 1894
218 Dodd, Benjamin, Bearpark Colliery, near Durham (*Member of Council*) ... ... S. May 3, 1866 M. Aug. 1, 1868
219 Dodd, M., Lemington Hall, Lemington-upon-Tyne ... ... S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
220 Dodd, Thomas Robert, P.O. Box 317, Johannesburg, Transvaal ... ... June 13, 1896
221 Donald, John Macintosh, Bantjes Consolidated Mines, Limited, Florida, South African Republic ... ... A.M. July 14, 1896 M. Oct. 10, 1896
222* Donkin, W., General Manager, Witbank Colliery, Per Special Post Bag, *via* Pretoria, South Africa ... ... S. Sept. 2, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
223* Douglas, C. P., Thornbeck Hill, Carmel Road, Darlington March 6, 1869
224 Douglas, John, 4, Brandling Terrace, Felling, R.S.O., Co. Durham ... ... A.M. April 22, 1882 M. Aug. 3, 1889
225 Douglas, M. H., Usworth Colliery, Washington, R.S.O., Co. Durham ... ... A.M. Aug. 2, 1879 M. Aug. 3, 1889
226 Douglas, T., The Garth, Darlington (Past-President, *Member of Council*) ... ... Aug. 21, 1852
227 Dowdeswell, H., Butterknowle Colliery, *via* Darlington ... S. April 5, 1873 M. Aug. 7, 1875
228 Doyle, Patrick, *Indian Engineering*, 19, Lall Bazar, Calcutta, India ... ... A.M. March 1, 1879 M. Aug. 3, 1889
229 Draper, David, P.O. Box 3517, Johannesburg, Transvaal Feb. 15, 1896
230 Dudley, Uriah, The White Rock Silver Mine, Limited, Drake, New South Wales ... ... April 14, 1894
231 Dumat, Alfred, 1, Loop Street, Pietermaritzburg, Natal April 8, 1893
232 Dyson, T. Ingleby, Aldershot, near Maryborough, Queensland, Australia ... ... Feb. 9, 1895

233 Eastlake, Arthur W., Balham, London, S.W. ... ... June 11, 1892
234 Ede, Francis J., Silchar, Cachar, India ... ... Aug 1, 1896
235 Ede, Henry Edward, c/o The New Explosives Company, Stowmarket, Suffolk... ... ... July 14, 1896
236 Eden, C. H., c/o Vivian and Sons, Swansea ... ... June 14, 1890
237 Edge, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop ... ... A.M. Sept. 7, 1878 M. Aug. 3, 1889
238 Edwards, Edward, Maindy Pit, Ocean Coal Company, Ton Pentre, South Wales ... ... Feb. 9, 1895
239 Edwards, Telford, Tati, Matabeleland, South Africa; and 1, Bradenham Place, Penarth, South Wales ... ... Dec. 12, 1896
240 Eissler, M., 5, Post Office Chambers, Sydney, New South Wales ... ... Feb. 15, 1896
241 Ellis, W. R., Wigan ... ... June 1, 1878
242 Elsdon, Robert, "Esperanza," 381, Hagley Road, Edgbaston, Birmingham ... ... Nov. 7, 1876
243 Elwen, Thomas Lee, Brandon Colliery, Durham ... ... Oct. 13, 1888
244 Embleton, H. C., Central Bank Chambers, Leeds ... ... April 14, 1894
245 Embleton, T. W., The Cedars, Methley, Leeds ... ... S. Sept. 2, 1865 M. Aug. 1, 1868
246 Epton, W. Martin, P.O. Box 737, Johannesburg, Transvaal Oct. 12, 1895
247 Esuman-Gwira, John Buckman, Cape Coast Castle, West Africa ... ... April 2, 1898

			Date of Election and of Transfer.
248	ETHERINGTON, J., 39A, King William Street, London Bridge, London, E.C.		Dec. 9, 1893
249	EVANS, LEWIS, P.O. Box 2691, Johannesburg, Transvaal ...		Oct. 14, 1893
250	EVERARD, J. B., 6, Millstone Lane, Leicester		March 6, 1869
251	FAIRLEY, JAMES, Craghead and Holmside Colliery, Chester-le-Street	A.M.	Aug. 7, 1880
		M.	Aug. 3, 1889
252	FARAGHER, LOUIS, Cape Copper Company, Limited, Ookiep, Namaqualand, South Africa		April 8, 1893
253	FARMER, A., Seaton Carew, near West Hartlepool		March 2, 1872
254	FELLOWS, ALFRED, The Bede Metal and Chemical Company, Limited, Hebburn, Newcastle-upon-Tyne ...		June 13, 1896
255*	FENWICK, BARNABAS, 37, Osborne Road, Newcastle-upon-Tyne		Aug. 2, 1866
256	FERENS, FREDERICK J., Silksworth Colliery, Sunderland ...	S.	Dec. 4, 1880
		A.M.	Aug. 4, 1888
		M.	Aug. 3, 1889
257	FERGIE, CHARLES, Drummond Colliery, Westville, Nova Scotia		Dec. 9, 1893
258	FERGUSON, C., Walbottle Colliery, Scotswood-upon-Tyne ...		Feb. 12, 1898
259	FERGUSON, D., c/o James Ferguson, 115, Buccleuch Street, Glasgow	A.M.	Dec. 8, 1883
		M.	Aug. 3, 1889
260	FERGUSON, JAMES, P.O. Box 253, Johannesburg, Transvaal		Dec. 12, 1896
261	FIGARI, ALBERTO, Apartado, 405, Lima, Peru		April 25, 1896
262	FISHER, EDWARD R., Blaina Lodge, Llandebie, R.S.O., Carmarthenshire	A.M.	Aug. 2, 1884
		M.	Aug. 3, 1889
263	FISHWICK, R., Binchester Colliery, Co. Durham		Aug. 6, 1892
264	FLETCHER, JAMES, Whickham and Bullock Island Coal Company, Limited, Carrington, New South Wales ...		Dec. 9, 1893
265	FLETCHER, LANCELOT, Brigham Hill, Cockermouth	A.M.	April 14, 1888
		M.	June 8, 1889
266*	FLETCHER, WALTER, The Hollins, Bolton, Lancashire ...		Dec. 14, 1895
267	FLINT, JOHN, Broomhill Colliery, Acklington, Northumberland		Jan. 19, 1895
268	FOOTE, ARTHUR DE WINTE, P.O. Box 491, Grass Valley, California, U.S.A.		Feb. 13, 1897
269	FORD, MARK, Sherburn Colliery, near Durham		Aug. 3, 1895
270	FORD, STANLEY H., P.O. Box 2056, Johannesburg, Transvaal		June 10, 1893
271	FORREST, J. C., Holly Bank Colliery, Essington, Wolverhampton		April 12, 1884
272	FORSTER, G. B., Farnley Hill, Corbridge-upon-Tyne (PAST-PRESIDENT. *Member of Council*)		Feb. 5, 1857
273	FORSTER, J. R., Water Company's Office, Newcastle-upon-Tyne		July 2, 1872
274	FORSTER, THOMAS E., 3, Eldon Square, Newcastle-upon-Tyne (*Member of Council*)	S.	Oct. 7, 1876
		A.M.	Aug. 1, 1885
		M.	June 8, 1889
275	FOWLER, R., Washington Colliery, Washington Station, R.S.O., Co. Durham...		Nov. 24, 1894
276	FRECHEVILLE, WILLIAM, Claremont, Nutfield, Redhill, Surrey		Feb. 15, 1896
277	FROSSARD, J. D., Orthes, Basses Pyrenees, France		Dec. 14, 1895
278	FRYAR, JOHN WILLIAM, Jobs Hill, Crook, *via* Darlington	A.	June 14, 1890
		M.	June 12, 1897
279	FRYAR, MARK, Denby Colliery, Derby	S.	Oct. 7, 1876
		A.M.	Aug. 4, 1883
		M.	June 8, 1889
280	FRYAR, WILLIAM, Inspector of Mines, Brisbane, Queensland, Australia		April 10, 1897
281	GALLOWAY, T. LINDSAY, Argyll Colliery, Campbeltown, N.B.		Sept. 2, 1876
282	GALLOWAY, WILLIAM, Cardiff		April 23, 1887
283	GALLWEY, ARTHUR P., P.O. Box 138, Johannesburg, Transvaal	S.	Oct. 2, 1880
		M.	Oct. 10, 1891
284	GARDINER, E. T., 8, South View Terrace, Bishop Auckland		Dec. 8, 1894

			Date of Election and of Transfer.
285	Geddes, George H., 21, Young Street, Edinburgh		Oct. 1, 1881
286	Gerrard, James, 9, Meek Buildings, Wigan...		S. March 1, 1873
		A.M.	Aug. 2, 1879
		M.	June 8, 1889
287	Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester...	S.	March 5, 1870
		M.	Aug. 1, 1874
288	Gifford, Henry J., 36, St. John's Road, Clifton, Bristol...		Oct. 14, 1893
289	Gilchrist, J. R., Garesfield Colliery, Lintz Green, Newcastle-upon-Tyne	S.	Feb. 3, 1877
		A.M.	Aug. 1, 1885
		M.	June 8, 1889
290	Gill, William, Apartado, 42, Bilbao, Spain		June 13, 1896
291	Gillman, Federico, Ingeniero de Minas, Gergal, Provincia de Almeria, Spain	A.M.	Dec. 8, 1894
		M.	June 8, 1895
292	Gilroy, S B., Mining Engineer, Mansfield		Sept. 5, 1868
293	Gipps, F. G. de Visme, Coolgardie, Western Australia ...		April 25, 1896
294	Gjers, John, Bournewood, Bournemouth		June 7, 1873
295*	Gledhill, Edward, c/o Andrew Hallett, Solicitor, Portland Street, Southampton		Dec. 9, 1893
296	Goerz, A., Manor House, St. John's Wood Park, London, N.W.		April 14, 1894
297	Goldsworthy, Arthur, Linares, Provincia de Jaen, Spain		Aug. 3, 1895
298	Goldsworthy, Christopher, Newquay, Cornwall... ...		June 12, 1897
299	Goolden, Walter T., c/o Easton, Anderson and Goolden, Limited, 2, St. Nicholas' Buildings, Newcastle-upon-Tyne		Aug. 6, 1892
300	Gordon, Robert, Imperial Chambers, Coolgardie, Western Australia		Dec. 12, 1896
301	Gouldie, Joseph, The Gill, Wigton, Cumberland		Aug. 5, 1893
302	Graham, Edward, Jun., East Howle Colliery, Ferryhill		Aug. 1, 1896
303	Greaves, J. O., Westgate, Wakefield		Aug. 7, 1862
304	Green, J. T., Southside, Sneyd Park, Clifton, Bristol ...		Dec. 3, 1870
305	Greener, Henry, South Pontop Colliery, Annfield Plain, R.S.O., Co. Durham...	A.M.	Dec. 9, 1882
		M.	Aug. 3, 1889
306	Greener, T. Y., West Lodge, Crook, Darlington	S.	July 2, 1872
		A.M.	Aug. 2, 1879
		M.	June 8, 1889
307	Greenwell, G. C., Jun., Poynton, near Stockport	S.	March 6, 1869
		M.	Aug. 3, 1872
308	Gregorie, Charles, Aberdare, South Wales		Oct. 9, 1897
309	Gregson, G. Ernest, 11, Chapel Street, Preston, Lancashire	A.M.	Dec. 8, 1894
		M.	Feb. 9, 1895
310	Gresley, W. S., Erie, Pennsylvania, U.S.A.	A.M.	Oct. 5, 1878
		M.	Aug. 3, 1889
311	Grey, C. G., Ballycourcy, Enniscorthy, Co. Wexford ...		May 4, 1872
312	Grey, Frederick William, Dashwood House, 9, New Broad Street, London, E.C.		July 14, 1896
313	Griffith, N. R., Plasnewydd, Ruabon, North Wales ...		Aug. 1, 1867
314	Griffith, William, Waterloo House, Aberystwyth, South Wales		Dec. 9, 1893
315	Griffiths, Edward	A.	June 13, 1891
		M.	Aug. 1, 1896
316	Grimshaw, E. J., 23, Hardshaw Street, St. Helen's, Lancashire		Sept. 5, 1868
317*	Grundy, James, 27, Chowringhee Road, Calcutta, India ...		June 13, 1896
318	Guthrie, James K., Prudential Buildings, Newcastle-upon-Tyne		Aug. 3, 1889
319	Haddock, W. T., Sutherland Reef, Limited, Leydsdorp, Zoutpansberg, South African Republic	S.	Oct. 7, 1876
		A.M.	Aug. 1, 1885
		M.	June 8, 1889
320	Haggie, D. H., Wearmouth Patent Rope Works, Sunderland		March 4, 1876
321	Haggie, Peter Sinclair, Gateshead-upon-Tyne	A.M.	April 14, 1883
		M.	Aug. 3, 1889
322*	Hague, Ernest, Castle Dyke, Sheffield	S.	March 2, 1878
		M.	Aug. 3, 1878

		Date of Election and of Transfer.
323	HALDER, ALBERT H., P.O. Box 213, Johannesburg, Transvaal	April 8, 1893
324	HALL, FREDERICK, Fernleigh, Highfield, Workington ...	Oct. 14, 1893
325	HALL, FRED. W., Tamworth Colliery, Alvecote, near Tamworth	S. June 8, 1889 M. Feb. 10, 1894
326	HALL, GEORGE WILLIAM, Coolgardie, Western Australia ..	Dec. 12, 1896
327	HALL, JOHN CHARLES, Pegswood Colliery, near Morpeth ...	A. Dec. 14, 1889 M. Aug. 3, 1895
328	HALL, M., Lofthouse Station Collieries, near Wakefield ...	Sept. 5, 1868
329	HALL, M. S., 8, Victoria Street, Bishop Auckland	Feb. 14, 1874
330	HALL, TOM, Ryhope Colliery, *via* Sunderland	June 8, 1889
331	HALL, WILLIAM F., Haswell Colliery, Haswell, *via* Sunderland (*Member of Council*)	May 13, 1858
332	HALLAS, G. H., Huyton, near Liverpool	S. Oct. 7, 1876 A.M. Aug. 4, 1883 M. June 8, 1889
333	HALLIMOND, WILLIAM TASKER, General Manager, Cape Collieries, Limited, Molteno, Cape Colony	Dec. 14, 1889
334	HALSE, EDWARD, Sucre, Puerto Berrio, Estado de Antioquia, Republic of Colombia, South America	A.M. June 13, 1885 M. Aug. 3, 1889
335	HAMILTON, E., Rig Wood, Saltburn-by-the-Sea	S. Nov. 1, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
336	HANCOCK, H. LIPSON, Moonta Mines, South Australia ...	Dec. 14, 1895
337	HANCOCK, H. R., Moonta Mines, South Australia	A.M. Aug. 4, 1894 M. Nov. 24, 1894
338	HANNAH, DAVID, Brynderwen, Ferndale, South Wales ...	Feb. 9, 1895
339	HARDMAN, JOHN E.	Dec. 9, 1893
340	HARE, SAMUEL, Bedlington Collieries, Bedlington, R.S.O., Northumberland	S. Aug. 2, 1879 M. Aug. 1, 1891
341	HARGREAVES, JOSEPH, Gwaun Cae Gurwen Collieries, Brynamman, R.S.O.	Aug. 5, 1893
342	HARLE, PETER, Page Bank Colliery, Co. Durham	Oct. 8, 1892
343	HARLE, RICHARD, Browney Colliery, Durham	April 7, 1877
344	HARRIS, G. E., Margherita, Debrugarh, Upper Assam ...	Feb. 10, 1894
345	HARRIS, W. S., Kibblesworth, Gateshead-upon-Tyne ...	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
346	HARRISON, C. A., North Eastern Railway, Newcastle-upon-Tyne	June 21, 1894
347	HARRISON, G. B., Swinton, near Manchester	Aug. 6, 1892
348	HARRISON, JONATHAN, Kimihia, Auckland, New Zealand ...	June 8, 1895
349	HARRISON, W. B., Brownhills Collieries, near Walsall ...	April 6, 1867
350	HARVEY, W. PELLEW, Vancouver, British Columbia ...	June 8, 1895
351	HASELDEN, ARTHUR, Linares, Provincia de Jaen, Spain ...	A.M. Dec. 11, 1897 M. April 2, 1898
352	HASELDEN, EUGENE KINNAIRD, Jardines No. 3, La Carolina, Provincia de Jaen, Spain	A.M. Dec. 11, 1897 M. June 11, 1898
353	HAWKER, EDWARD WILLIAM, Adelaide Club, Adelaide, South Australia	Oct. 12, 1895
354	HAY, J., Jun., Widdrington Colliery, Acklington	S. Sept. 4, 1869 M. Aug. 4, 1874
355	HEAD, JEREMIAH, 47, Victoria Street, Westminster, London, S.W.	Aug. 3, 1889
356	HEDLEY, J. L., H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (VICE-PRESIDENT, *Member of Council*)	S. Feb. 5, 1870 M. Aug. 2, 1873
357	HEDLEY, SEPTIMUS H., Langholme, Roker, Sunderland ...	S. Feb. 15, 1879 A.M. Aug. 1, 1885 M. Aug. 3, 1889
358	HEDLEY, WILLIAM, Ouston House, Chester-le-Street ...	Feb. 13, 1897
359	HEINZE, F. AUG., Trail, British Columbia	Dec. 11, 1897
360	HENDERSON, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
361	HENDERSON, JOSEPH J., U.S. Engineer's Office, Kingsbridge, New York, U.S.A.	June 13, 1891
362	HENDY, J. C. B., Etherley, *via* Darlington	Oct. 14, 1893

		Date of Election and of Transfer.
363	Hepburn, Wheldon, Littletown Colliery, near Durham	Aug. 3, 1895
364	Heppell, T., Leafield House, Birtley, Chester-le-Street	Aug. 6, 1863
365	Heslop, C., Woodside, Marske Mill Lane, Saltburn-by-the-Sea	S. Feb. 1, 1868
		M. Aug. 2, 1873
366	Heslop, Grainger, Deptford Hall, Sunderland	Oct. 5, 1872
367	Heslop, Michael, Rough Lea Colliery, Willington, Co. Durham	A. Feb. 10, 1894
		M. June 21, 1894
368	Heslop, Septimus, New Beerbhoom Coal Company, Limited, Asansol, Bengal, India	Oct. 12, 1895
369	Heslop, Thomas, Storey Lodge Colliery, Cockfield, *via* Darlington	S. Oct. 2, 1880
		A.M. Aug. 4, 1888
		M. Aug. 3, 1889
370	Heslop, William Taylor, P.O. Box 93, Boksburg, South African Republic	Aug. 3, 1895
371*	Hewitt, G. C., Serridge House, Coalpit Heath, near Bristol	June 3, 1871
372	Hewlett, A., Haseley Manor, Warwick	March 7, 1861
373	Hewlett, Erne, Ammanford Colliery Company, Limited, Ammanford, R.S.O., Carmarthenshire	Oct. 10, 1896
374	Higby, Robert George, Borrea Coal Company, Limited, Salanpore Collieries, Seetarampore, Bengal, India	Dec. 9, 1893
375	Higson, Jacob, 18, Booth Street, Manchester	Aug. 7, 1862
376	Hill, Leslie, Rossland, British Columbia	A.M. Aug. 1, 1896
		M. Dec. 12, 1896
377	Hill, William, Dordon, Tamworth	A.M. June 9, 1883
		M. Aug. 3, 1889
378*	Hilton, J., Woodcock Hall, Newburgh, near Southport	S. Dec. 7, 1867
		M. Aug. 6, 1870
379	Hilton, T. W., Wigan Coal and Iron Company, Limited, Wigan	Aug. 3, 1865
380	Hobson, J. B., Cariboo Hydraulic Mining Company, Limited, Vancouver, British Columbia	April 25, 1896
381	Hodge, Francis, Coromandel, near Auckland, New Zealand	April 14, 1894
382	Hodgson, Jacob, Cornsay Colliery, Co. Durham	June 8, 1895
383	Hodgson, John, Edmondsley Colliery, Chester-le-Street	Oct. 8, 1889
384	Hoffman, Charles, Per Private Bag, P.O. Box 1022, Johannesburg, Transvaal	June 13, 1896
385	Hogg, C. E., 1, St. Helen's Place, London, E.C.	Oct. 12, 1895
386	Holliday, Martin F., Langley Grove, Durham	May 1, 1875
387	Hollis, Henry William, Whitworth House, Spennymoor	June 8, 1889
388	Holt, John, Jun., 109, Manchester Road, Swinton, Lancashire; and The Hollies, Heywood, Lancashire	Aug. 5, 1893
389	Hood, A., 6, Bute Crescent, Cardiff	May 2, 1861
390	Hooper, Edward, c/o Bewick, Moreing and Company, Broad Street House, New Broad Street, London, E.C.	A.M. June 4, 1881
		M. April 14, 1894
391	Hooper, G. C., General Manager, The Afrikander Gold Mining Company, Limited, Klerksdorp, South African Republic	A.M. Aug. 4, 1894
		M. Oct. 13, 1894
392	Hope, Edmund Louis, Dandot, Ihelum, Punjaub, India	Oct. 9, 1897
393	Hopkins, Edward, 13, Harrington Gardens, London, S.W.	Oct. 8, 1889
394	Hosking, James, Roskear, Camborne, Cornwall	June 21, 1894
395	Hoskold, Carlos A. Lynes, First Engineer, Inspector of the National Department of Mines and Geology, Calle Charcas, 1222, Buenos Aires, Argentine Republic	June 8, 1895
396	Hoskold, H. D., Inspector General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Buenos Aires, Argentine Republic	April 1, 1871
397	House, John, Rosebridge and Douglas Bank Collieries Company, Limited, Wigan	June 13, 1896
398	Howes, Frank T., Singareni Collieries, Hyderabad Deccan Company, Limited, Secundarabad, India	A. Dec. 10, 1892
		M. Oct. 14, 1893
399	Howley, James Patrick, Geological Survey of Newfoundland, Museum and Office, P.O. Building, St. John's, Newfoundland	Aug. 1, 1896
400	Hudson, James O., Menzies, Western Australia	April 2, 1898

		Date of Election and of Transfer.
401	Humble, William, Lawson Street, Hamilton, Newcastle, New South Wales	Oct. 14, 1893
402	Hurst, George, 9, Framlington Place, Newcastle-upon-Tyne	S. April 14, 1883 M. Aug. 1, 1891
403	Hutchinson, R. L., 83, Howard Street, North Shields .	June 13, 1896
404	Jackson, W. G., High Prestwick, Chiddingfold, Surrey ...	June 7, 1873
405	Jaffrey, William, 3, Victoria Street, London, S.W. ...	Feb. 13, 1897
406	James, John, c/o Mrs. Corkhill, 13, Gladys Road, West Hampstead, London, N.W.	June 12, 1897
407	James, William Henry Trewartha, 38, Aberdare Gardens, West Hampstead, London, N.W.	Dec. 12, 1896
408	Jeffcock, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
409	Jefferson, Frederick, Whitburn Colliery, South Shields	Dec. 11, 1897
410	Jenkins, Charles Warren Bowen, Kalgoorlie Central Gold Mine, P.O. Box 153, Kalgoorlie, Western Australia	Oct. 9, 1897
411	Jenkins, W., Ocean Collieries, Treorchy, Glamorganshire ..	Dec. 6, 1862
412	Jepson, H., 39, North Bailey, Durham	S. July 2, 1872 A.M. Aug. 2, 1879 M. June 8, 1889
413	Jobling, John William, Clifton Cottage, Burnley, Lancashire	June 13, 1896
414*	Jobling, Thomas E., Bebside, Northumberland (*Member of Council*)	S. Oct. 7, 1876 A.M. Aug. 4, 1883 M. June 8, 1889
415*	Johns, J. Harry, P.O. Box 1021, Johannesburg, Transvaal	June 21, 1894
416	Johnson, Algernon Edward, County Court Building, Wrexham	April 25, 1896
417	Johnson, J., The Terrace, Stairfoot, near Barnsley ...	March 7, 1874
418	Johnson, W., Abram Colliery, Wigan	S. Feb. 14, 1874 A.M. Aug. 2, 1879 M. June 8, 1889
419	Johnston, Duncan Stuart, P.O. Box 116, Johannesburg, Transvaal	Feb. 15, 1896
420	Johnston, J. Howard, c/o Backus and Johnston, Lima, Peru, South America	Feb. 10, 1894
421	Joicey, J. G., Forth Banks West Factory, Newcastle-upon-Tyne	April 10, 1869
422	Joicey, W. J., Sunningdale Park, Berkshire	March 6, 1869
423	Jones, John Arthur, Gijon, Asturias, Spain...	April 8, 1893
424	Jones, Jacob Carlos, Bellambi, New South Wales	Aug. 6, 1892
425	Jones, Thomas, 1, Princes Street, Great George Street, London, S.W.	June 12, 1897
426	Kanda, Reiji, Shikaibetsu Silver and Lead Mines, Yoichi, Hokkaido, Japan	A.M. Aug. 4, 1894 M. Nov. 24, 1894
427	Kaufman, Charles, St. George's Terrace, Perth, Western Australia	Oct. 12, 1895
428	Kay, Robert, South Tanfield Colliery, Stanley, R.S.O., Co. Durham	Aug. 4, 1894
429	Kayll, A. C., Gosforth, Newcastle-upon-Tyne (*Member of Council*)	S. Oct. 7, 1876 M. Aug. 3, 1889
430	Kayser, H. W. Ferdinand, The Mount Bischoff Tin Mining Company, Waratah, Tasmania	Nov. 24, 1894
431	Kebler, Julian A., Boston Building, Denver, Colorado, U.S.A.	June 13, 1896
432	Kellett, Matthew H., St. Helen's Colliery, Bishop Auckland	S. April 11, 1891 M. Aug. 3, 1895
433	Kellett, William, Portland Bank, Southport	June 1, 1878
434	Kennedy, Prof. George Thomas, King's College, Windsor, Hants County, Nova Scotia	A.M. Oct. 10, 1896 M. April 2 1898
435	Kennedy, William, 509, West Sixth Street, Austin, Texas, U.S.A.	Jan. 19, 1895
436	Kerry, Thomas Caradoc, 168 and 169, Dashwood House, New Broad Street, London, E.C.	April 10, 1897

		Date of Election and of Transfer.
437	KIDD, THOMAS, Jun., Linares, Provincia de Jaen, Spain. *Transactions* to be sent to c/o Thomas Kidd, 104, Balham Park Road, Balham, London, S.W.	Aug. 3, 1895
438	KIRKBY, J. W., Kirkland, Leven, Fife	Feb. 1, 1873
439	KIRKUP, AUSTIN, Newbottle Colliery, Bunker Hill, Fence Houses	S. April 9, 1892 M. June 12, 1897
440	KIRKUP, J. P., Burnhope, Lanchester	April 11, 1891
441	KIRKUP, PHILIP, Cornsay Colliery Office, Esh, near Durham	S. March 2, 1878 A.M. Aug. 7, 1886 M. Aug. 3, 1889
442	KIRTON, HUGH, Kimblesworth Colliery, Chester-le-Street ...	S. April 7, 1877 A.M. Aug. 1, 1885 M. June 8, 1889
443	KLAUKE, JOSEF, High Green, Tankersley, near Barnsley ...	Feb. 13, 1897
444*	KNOWLES, ROBERT, Ednaston Lodge, Derby	April 10, 1886
445	KONDO, R., 7, Setomoncho, Nihonbashi, Tokio, Japan ...	June 21, 1894
446*	KWANG, KWONG YUNG, Chinese Engineering and Mining Company, Lin Si Colliery, Tientsin, North China ...	June 8, 1895
447	LABRAM, GEORGE FREDERICK, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Aug. 7, 1897
448	LAMB, R. O., West Denton, Newcastle-upon-Tyne	Aug. 2, 1866
449	LANCASTER, JOHN, Ashlawn, Rugby	March 2, 1865
450	LANCASTER, JOHN, Auchinheath, Southfield and Fence Collieries, Lesmahagow	Sept. 7, 1878
451	LANDALE, A., Comely Park Place, Dunfermline	Dec. 2, 1858
452	LANDERO, CARLOS F. DE, c/o Real del Monte Company, P.O. Box 1, Pachuca, Mexico	Feb. 15, 1896
453*	LAPORTE, H , 57, Rue de la Concorde, Brussels	May 5, 1877
454	LAVERICK, JOHN WALES, Tow Law Colliery Office, Tow Law, R.S.O., Co. Durham	A.M. Dec. 9, 1882 M. Aug 3, 1889
455	LAVERICK, ROBERT, West Rainton, Fence Houses	Sept. 2, 1876
456	LAWN, JAMES GUNSON, South African School of Mines, Kimberley, South Africa	July 14, 1896
457	LAWRENCE, H., 24, Grainger Street West, Newcastle-upon-Tyne (*Member of Council*)	Aug. 1, 1868
458	LAWRENCE, H. L., 19, Walpole Terrace, Brighton	April 8, 1893
459	LAWS, W. G., Town Hall, Newcastle-upon-Tyne	Oct. 2, 1880
460	LEACH, C. C., Seghill Colliery, Northumberland	S. March 7, 1874 A.M. Aug. 6, 1881 M. Aug. 4, 1883
461	LEBOUR, G. A., Durham College of Science, Newcastle-upon-Tyne	Feb. 1, 1873
462	LECK, WILLIAM, H.M. Inspector of Mines, Cleator Moor, Cumberland	Nov. 24, 1894
463	LECKIE, ROBERT G., Londonderry Iron Company, Limited, Londonderry, Nova Scotia	Dec. 9, 1893
464	LEE, J. W. R., 70, St. Helen's Gardens, North Kensington, London, W.	Aug. 5, 1893
465	LEWIS, H. R., Finsbury Circus Buildings, London, E.C. ...	April 14, 1894
466	LEWIS, JOHN DYER, H.M. Inspector of Mines, 183, Richmond Road, Roath, Cardiff	Oct. 9, 1897
467	LEWIS, SIR WILLIAM THOMAS, Bart., Mardy, Aberdare (VICE-PRESIDENT, *Member of Council*)	Sept. 3, 1864
468	LIDDELL, JOHN	July 14, 1896
469	LIDDELL, J. M., 3, Victoria Villas, Newcastle-upon-Tyne ...	S. March 6, 1875 A.M. Aug. 6, 1881 M. June 8, 1889
470	LIEBERT, R. A. D.	April 8, 1893
471	LINDAY, GEORGE, Blackett Colliery, Haltwhistle	June 10, 1893
472	LINDOP, A. B., Westport Coal Company, Limited, Denniston, Westport, New Zealand	Dec. 9, 1893
473	LISHMAN, R. R., Bretby Colliery, Burton-upon-Trent ...	S. June 9, 1883 M. Aug. 1, 1891

		Date of Election and of Transfer.
474	LISHMAN, T., Hetton Colliery, Hetton-le-Hole, R.S.O., Co. Durham	S. Nov. 5, 1870 M. Aug. 3, 1872
475	LISHMAN, WILLIAM, Holly House, Witton-le-Wear	April 1, 1858
476	LISHMAN, W. ERNEST, Boldon Colliery, R.S.O., Co. Durham	June 10, 1893
477	LISLE, J., Cambrian House, Kimberley, South Africa	S. July 2, 1872 A.M. Aug. 3, 1878 M. June 8, 1889
478	LITTLE, GILBERT, Transport Appliance Works, Smethwick, Birmingham	April 27, 1895
479	LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London, W.	S. Sept. 1, 1877 A.M. Aug. 2, 1884 M. Aug. 3, 1889
480	LIVESEY, C., Bradford Colliery, near Manchester	Aug. 3, 1865
481	LIVESEY, T., Bradford Colliery, near Manchester	S. Nov. 7, 1874 M. Aug. 7, 1875
482	LLEWELLIN, DAVID MORGAN, Glanwern Offices, Pontypool	May 14, 1881
483	LLOYD, G. HAMILTON, 7, St. Mildred's Court, Poultry, London, E.C.	Dec. 9, 1893
484	LOCKWOOD, ALFRED ANDREW, c/o Indo-China Company, 29, Cornhill, London, E.C.	June 12, 1897
485	LOGAN, WILLIAM, Langley Park Colliery, Durham (*Member of Council*)	Oct. 5, 1867
486	LONGRIDGE, Captain CECIL CLEMENT, Grove Cottage, Gravesend	Aug. 1, 1896
487	LONGRIDGE, JETHRO, Burradon and Hazelrigg Collieries, South Gosforth, Newcastle-upon-Tyne	Dec. 14, 1889
488	LORD, EDWARD IVEAGH, Greymouth, Westland, New Zealand	Dec. 12, 1896
489	LOUIS, D. A., 77, Shirland Gardens, London, W.	April 8, 1893
490	LOUIS, HENRY, 11, Summerhill Terrace, Newcastle-upon-Tyne (*Member of Council*)	Feb. 15, 1896
491	LOVELY, W. H. C., 101, Leadenhall Street, London, E.C.	June 8, 1895
492	LOWDON, THOMAS, Hamsteels, near Durham	Dec. 14, 1889
493	LUPTON, A., 6, De Grey Road, Leeds	Nov. 6, 1869
494	MACARTHUR, JOHN S., 108A, Hope Street, Glasgow	April 8, 1893
495	MACCABE, H. O., Russell Vale, Wollongong, New South Wales	S. Sept. 7, 1878 A.M. Aug. 7, 1880 M. Aug. 3, 1889
496	MCCARTHY, E. T., c/o Colonel Pigott, Archer Lodge, Charles Road, St. Leonards-on-the-Sea	A.M. Oct. 8, 1887 M. Aug. 3, 1889
497	MCCREATH, J., 208, St. Vincent Street, Glasgow	March 5, 1870
498	MCGEACHIE, DUNCAN, Waratah Colliery, Charlestown, near Newcastle, New South Wales	Nov. 24, 1894
499	MACKINTOSH, JAMES, Lamancha P.O., Peeblesshire	Oct. 12, 1895
500	MCMURTRIE, GEORGE EDWIN JAMES, Foxes Bridge Colliery, Cinderford, Gloucestershire	S. Aug. 2, 1884 M. Dec. 12, 1891
501	MCMURTRIE, J., Radstock Colliery, Bath	Nov. 7, 1863
502	MCNEILL, BEDFORD, 25A, Old Broad Street, London, E.C.	Dec. 11, 1897
503	MADDISON, THOMAS R., Dircar House, near Wakefield	S. March 3, 1877 A.M. Aug. 6, 1881 M. June 8, 1889
504	MADDISON, W. H. F., The Lindens, Darlington	June 14, 1890
505	MALING, C. T., Ellison Place, Newcastle-upon-Tyne	Oct. 5, 1872
506	MAMMATT, J. E., 1, Albion Place, Leeds	Aug. 3, 1865
507	MANNING, ARTHUR HOPE, P.O. Box 88, Heidelberg, Transvaal	Dec. 11, 1897
508	MARKHAM, G. E., Coundon, Bishop Auckland	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
509	MARKS, HERBERT T., New Broad Street House, London, E.C.	Feb. 15, 1896
510	MARLEY, J. W., Thornfield, Darlington	S. Aug. 1, 1868 M. Aug. 2, 1873
511*	MARRIOTT, HUGH FREDERICK, c/o H. Eckstein and Company, P.O. Box 149, Johannesburg, Transvaal	Dec. 12, 1896

		Date of Election and of Transfer.
512	MARTEN, E. B., Pedmore, near Stourbridge	July 2, 1872
513	MARTIN, C. W., Newbottle Colliery Offices, Fence Houses (*Member of Council*)	Aug. 6, 1892
514	MARTIN, HENRY W., Trewern, Dowlais, Glamorganshire ...	Oct. 9, 1897
515	MARTIN, RALPH, The Cardigan Stone Company, Limited, Llandyssil, South Wales	Oct. 12, 1895
516	MASON, FRANCIS HERBERT, Queen Building, Hollis Street, Halifax, Nova Scotia	June 8, 1895
517	MATHIESON, ALEXANDER, Hetton Colliery, Carrington, near Newcastle, New South Wales	Nov. 5, 1892
518	MATTHEW, WILLIAM	June 21, 1894
519	MATTHEWS, D. H. F., H.M. Inspector of Mines, Hoole, Chester	Nov. 24, 1894
520	MATTHEWS, J., c/o R. and W. Hawthorn, Newcastle-upon-Tyne	A.M. April 11, 1885 M. Aug. 3, 1889
521	MATTHEWS, R. F., Harehope Hall, Alnwick	March 5, 1857
522	MAWSON, R. BRYHAM, Brick House, Westleigh, near Manchester	June 11, 1892
523	MAY, GEORGE, The Harton Collieries, South Shields (PAST-PRESIDENT, *Member of Council*)	March 6, 1862
524	MELDRUM, J. J., Atlantic Works, City Road, Manchester	Nov. 24, 1894
525	MELLON, HENRY, Brook Lea, Askam-in-Furness	April 25, 1896
526	MERIVALE, J. H., Togston Hall, Acklington, Northumberland (*Member of Council*)	May 5, 1877
527*	MERIVALE, W., Managing Director, Barbados Railway, Barbados, W.I.	A.M. March 5, 1881 M. Aug. 3, 1889
528	MERRITT, W. HAMILTON, 90, Bloor Street East, Toronto, Ontario, Canada	Oct. 14, 1893
529	METCALF, A. T., Joe's Reef United (Sheba), Limited, Eureka City, De Kaap, South African Republic ...	June 21, 1894
530	MEYSEY-THOMPSON, A. H., Sun Foundry, Leeds	A.M. April 3, 1889 M. Aug. 3, 1889
531	MIDDLETON, ROBERT, Sheep Scar Foundry, Leeds	Aug. 1, 1891
532	MILLER, GEORGE APPLEBY BARTRAM, Barnsley House, Leighton Road, Southville, Bristol	June 13, 1896
533	MILLER, JAMES, Minas de Sao Bento, Santa Babara de Matto Dentro, Minas Geraes, Brazil	Aug. 4, 1894
534	MILLER, J. P. K., H. C. Frick Coke Company, Scottdale, Pennsylvania, U.S.A.	Dec. 14, 1895
535	MITCHINSON, R., Pontop Colliery, Annfield Plain, R.S.O., Co. Durham	Feb. 4, 1865
536	MOLE, WILLIAM FREDERICK DE, Coolgardie, Western Australia	Dec. 12, 1896
537	MOLSON, C. ATKINSON, c/o Montana National Bank, Helena, Montana, U.S.A.	Oct. 12, 1895
538	MONKHOUSE, JOSEPH, Gilcrux, Carlisle	June 4, 1863
539	MOORE, R. T., 156, St. Vincent Street, Glasgow	Oct. 8, 1892
540	MOORE, R. W., Somerset House, Whitehaven	S. Nov. 5, 1870 M. Aug. 4, 1877
541	MOORE, WILLIAM, Loftus Mines, Loftus-in-Cleveland, R.S.O.	A.M. Nov. 19, 1881 M. Aug. 3, 1889
542	MOREING, C. A., Broad Street House, Old Broad Street, London, E.C.	Nov. 7, 1874
543	MORGAN, JOHN, Norseman Gold Mining Company, Limited, Norseman, Western Australia	Aug. 7, 1897
544	MORISON, JOHN, Cramlington House, Northumberland ..	A.M. Dec. 4, 1880 M. Aug. 3, 1889
545	MORLAND-JOHNSON, EDWARD THOMAS, Brynn Bowydd, Blaenau Festiniog, North Wales	April 10, 1897
546	MORRIS, WILLIAM, Waldridge Colliery, Chester-le-Street ...	Oct. 8, 1892
547	MORSE, WILLARD S., Apartado 207, Monterey, Nuevo Leon, Mexico	June 13, 1896
548*	MORTON, H. J., 2, Westbourne Villas, Scarborough ...	Dec. 5, 1856
549	MOSES, WILLIAM, The Transvaal Coal Trust Company, Limited, Brakpan Colliery, Johannesburg, Transvaal, per Brakpan Private Bag	June 21, 1894

		Date of Election and of Transfer.
550	MOUNTAIN, WILLIAM C., Forth Banks, Newcastle-upon-Tyne	April 9, 1892
551	MUNDLE, ARTHUR, Bank Chambers, 24, Grainger Street West, Newcastle-upon-Tyne	S. June 5, 1875 M. Aug. 4, 1877
552*	NASSE, GEHEIMER OBERBERGRATH RUDOLPH, Dörnbergstrasse, 6, Berlin W., Germany	Sept. 4, 1869
553	NEAVE, HENRY EDWARD, c/o Post Office, Rossland, British Columbia	A.M. Aug. 1, 1896 M. Dec. 12, 1896
554	NEVIN, JOHN, Littlemoor, Mirfield, Normanton	S. May 2, 1868 M. Aug. 5, 1871
555	NEWBIGIN, H. THORNTON, 15, Chester Crescent, Newcastle-upon-Tyne	Oct. 13, 1894
556	NEWTON, JAMES, Whitehaven Colliery, Whitehaven ...	Nov. 5, 1892
557	NICHOL, WILLIAM, De Beers Mine, Kimberley, South Africa	A.M. Oct. 9, 1886 M. Aug. 3, 1889
558	NICHOLSON, ARTHUR DARLING, H.M. Inspector of Mines, 14, Chatsworth Square, Carlisle	S. June 13, 1885 A. Aug. 4, 1894 M. Feb. 12, 1898
559	NICHOLSON, J. COOK, Collingwood Street, Newcastle-upon-Tyne	Feb. 10, 1894
560	NICHOLSON, J. H., Cowpen Colliery Office, Blyth	S. Oct. 1, 1881 A. Aug. 3, 1889 M. April 8, 1893
561	NICHOLSON, MARSHALL, Middleton Hall, Leeds	Nov. 7, 1863
562	NOBLE, THOMAS GEORGE, Sacriston Colliery, Durham	A. Feb. 13, 1892 M. June 8, 1895
563	NORTH, F. W., 18, St. Swithin's Lane, London, E.C. ...	Oct. 6, 1864
564	NORTHCOTT, CECIL E., c/o G. Graves Gifford and Company, Chancery Chambers, Coolgardie, Western Australia ...	A.M. June 13, 1896 M. Feb. 13, 1897
565	OATES, ROBERT J. W., Manager, Government Central Provinces Collieries, Umaria, *via* Katni, C.P., India ...	S. Feb. 10, 1883 A.M. Aug. 1, 1891 M. Dec. 12, 1891
566	O'DONAHUE, THOMAS ALOYSIUS, 35, Princess Street, Wigan	A.M. Dec. 14, 1895 M. Oct. 9, 1897
567	OLDHAM, GEORGE, 25, Western Hill, Durham	Nov. 5, 1892
568	OLIVER, SEPTIMUS, Tyne House, Tynemouth	Nov. 24, 1894
569	ORCHARD, ALBERT JOHN ALFRED, The White House, Nailstone Colliery, near Leicester	Feb. 12, 1898
570*	OSHIMA, ROKURO, Hokkaido Colliery and Railway, Sapporo, Japan	April 10, 1897
571	ORNSBY, ROBERT EMBLETON, Seaton Delaval Colliery, Northumberland	June 11, 1898
572	PALMER, CLAUDE B., Wardley Hall, near Newcastle-upon-Tyne	A.M. Nov. 5, 1892 M. June 8, 1895
573	PALMER, HENRY, Medomsley, R.S.O., Co. Durham (*Member of Council*)	S. Nov. 2, 1878 A.M. Aug. 4, 1883 M. Aug. 3, 1889
574	PAMELY, C., Wye Cliffe House, Welsh Street, Chepstow ...	S. Sept. 5, 1868 M. Aug. 5, 1877
575	PANTON, F. S., Silksworth Colliery, Sunderland ...	S. Oct. 5, 1867 M. Aug. 4, 1874
576	PARRINGTON, M. W., Wearmouth Colliery, Sunderland ...	S. Dec. 1, 1864 M. Aug. 6, 1870
577	PARSONS, HON. CHARLES ALGERNON, Holeyn Hall, Wylam-upon-Tyne	A.M. June 12, 1886 M. Aug. 3, 1889
578	PASCOE, THOMAS, Bank of Australasia, London	A.M. April 10, 1897 M. June 12, 1897
579	PEAKE, R. C., Dunston House, near Stafford .. .	S. Feb. 7, 1880 A.M. Aug. 7, 1886 M. Aug. 3, 1889
580	PEASE, SIR J. W., Bart., Hutton Hall, Guisbrough, Yorkshire	March 5, 1857
581	PEEL, ROBERT, New Brancepeth Colliery, Durham . .	Aug. 6, 1892

		Date of Election and of Transfer.
582	PEILE, WILLIAM, c/o S. Neumann and Company, P.O. Box 485, Johannesburg, Transvaal	S. Oct. 1, 1863 M. Aug. 6, 1870
583	PERCY, C. M., King Street, Wigan	Dec. 14, 1895
584	PERNOLET, ARTHUR, 87, Rue Lafayette, Paris, France	Dec. 14, 1895
585	PHILLIPS, WILLIAM BATTLE, P.O. Box 346, Birmingham, Alabama, U.S.A.	June 12, 1897
586	PILE, WILLIAM, P.O. Box 1093, Johannesburg, Transvaal	Aug. 7, 1897
587	PLUMMER, JOHN, H.M. Inspector of Mines, Bishop Auckland	June 8, 1889
588	POTTER, A. M., Beaconfield, Corbridge-upon-Tyne (*Member of Council*)	S. Feb. 3, 1872 M. Aug. 5, 1876
589	POTTER, C. J., Heaton Hall, Newcastle-upon-Tyne	Oct. 3, 1874
590	PRICE, S. R., c/o Forster Brown and Rees, 12, Victoria Street, Westminster, London, S.W.	S. Nov. 3, 1877 A.M. Aug. 1, 1885 M. Aug. 3, 1889
591	PRICE, S. WARREN, 25, Lochaber Street, Cardiff	Aug. 3, 1895
592	PRICE-WILLIAMS, R., Victoria Mansions, 32, Victoria Street, London, S.W.	Feb. 10, 1894
593	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
594*	PRIOR, EDWARD G., Victoria, British Columbia. *Transactions*, etc., to be sent to William McGregor, Nanaimo, British Columbia	Feb. 7, 1880
595	PRITCHARD, EDWARD, 37, Waterloo Street, Birmingham	Dec. 12, 1896
596	PRITCHETT, C. W., Jun., Apartado Postal, 856, Mexico, D.F.	Dec. 9, 1893
597	PROUT, JAMES, 16, Claremont Road, Redruth, Cornwall	Feb. 10, 1894
598	PROUST, RENE	June 21, 1894
599	RAMSAY, J. A., Sherburn and Littletown Collieries, near Durham (*Member of Council*)	March 6, 1869
600	RAMSAY, WILLIAM, Tursdale, Co. Durham	Sept. 11, 1875
601	RANDOLPH, BEVERLEY S., Frostburg, Maryland, U.S.A.	Aug. 4, 1894
602	RAVENSHAW, H. W., 110, Cannon Street, London, E.C.	Feb. 15, 1896
603	REDMAYNE, R. A. S., Seaton Delaval Colliery, Newcastle-upon-Tyne	S. Dec. 13, 1884 M. Dec. 12, 1891
604	REDWOOD, BOVERTON, Glenwathen, Church End, Finchley, London, N.	June 21, 1894
605	REED, FRANK, Perth, Western Australia	April 25, 1896
606	REES, ROBERT THOMAS, Glandare, Aberdare, South Wales	Aug. 7, 1897
607	REES, WILLIAM THOMAS, Maesyffynon, Aberdare, South Wales	A.M. Oct. 9, 1897 M. Feb. 12, 1898
608	REID, A. H., 20, South African Chambers, St. George Street, Cape Town	June 21, 1894
609	REID, FRANCIS, 13, Railway Arches, Westgate Road, Newcastle-upon-Tyne	April 9, 1892
610	RENWICK, T. C., Lumley Thicks, Fence Houses	April 14, 1894
611	RHODES, C. E., Car House, Rotherham	Aug. 4, 1883
612	RHODES, F. B. F., Superintendent of the National Smelting and Refining Company, South Chicago, Illinois, U.S.A.	Feb. 10, 1894
613	RICH, WILLIAM, Minas de Rio Tinto, Provincia de Huelva, Spain	A.M. June 9, 1888 M. Aug. 3, 1889
614	RICHARDS, ARTHUR	June 13, 1896
615	RICHARDS, T. J.	Oct. 10, 1896
616	RICHARDSON, H., Backworth Colliery, Newcastle-upon-Tyne	March 2, 1865
617	RICHARDSON, RALPH, Barrow Collieries, Barnsley	S. June 9, 1883 M. Aug. 1, 1891
618	RICHARDSON, ROBERT, Blaydon Main Colliery, Blaydon-upon-Tyne	A. Feb. 8, 1890 M. Aug. 3, 1895
619	RIDLEY, N. B., 2, Collingwood Street, Newcastle-upon-Tyne	June 8, 1895
620	RIDLEY, WILLIAM, Gilpin House, Houghton-le-Spring	April 10, 1897
621	RIDYARD, J., Hilton Bank, Little Hulton, Bolton-le-Moors, Lancashire	Nov. 7, 1874
622	RITSON, U. A., 15, Queen Street, Newcastle-upon-Tyne	Oct. 7, 1871
623	ROBERTS, JAMES, Jun., Perranporth, R.S.O., Cornwall	Dec. 14, 1895

		Date of Election and of Transfer.
624	ROBERTS, ROBERT, Oakley Slate Quarries Company, Limited, Blaenau Festiniog, North Wales	Oct. 12, 1895
625	ROBERTSON, ANDREW, 49, Mining Exchange, Ballarat, Victoria, Australia	Aug. 7, 1897
626	ROBERTSON, D. A. W., Metropolitan Colliery, Helensburgh, near Sydney, New South Wales	Aug. 6, 1892
627*	ROBERTSON, J. R. M., Linton, Pitt Street, Milson's Point, Sydney, New South Wales	Aug. 2, 1890
628	ROBERTSON, W., 123, St. Vincent Street, Glasgow	March 5, 1870
629	ROBESON, ANTHONY MAURICE, De Beers Consolidated Mines, Limited, Kimberley, South Africa	June 13, 1896
630*	ROBINS, SAMUEL M., Nanaimo, British Columbia	Oct. 12, 1895
631	ROBINSON, C., Steenkampskraal, Hanover, Cape Colony	Dec. 9, 1893
632	ROBINSON, G. C., Brereton and Hayes Colliery, Rugeley, Staffordshire	Nov. 5, 1870
633	ROBINSON, JOHN, The Grange, Haydock, near St. Helens, Lancashire	Aug. 1, 1896
634	ROBINSON, J. B., Hedley Hill Colliery, Waterhouses	Aug. 5, 1893
635	ROBINSON, JOHN THOMAS, South Medomsley Colliery, Dipton, R.S.O.	Feb. 13, 1892
636	ROBINSON, R., Howlish Hall, near Bishop Auckland (VICE-PRESIDENT, *Member of Council*)	Feb. 1, 1868
637	ROBSON, J. S., Butterknowle Colliery, *via* Darlington	May 15, 1862
638	ROBSON, T. O., Chowdene Cottage, Low Fell, Gateshead-upon-Tyne (*Member of Council*)	S. Sept. 11, 1875 A.M. Aug. 2, 1884 M. June 8, 1889
639	ROCHESTER, WILLIAM, River View, Blaydon-upon-Tyne	Dec. 13, 1891
640	ROGERS, J. M., Wingfield House, Mount Hawk, near Scorrier, St. Agnes, Cornwall	June 13, 1896
641	ROLKER, CHARLES M., Mining and Financial Trust Syndicate, Limited, 6, Drapers Gardens, London, E.C.	June 8, 1895
642	RONALDSON, J. H., 76, Pitt Street, Sydney, New South Wales	Aug. 6, 1892
643	ROSCAMP, J., Shilbottle Colliery, Lesbury, R.S.O., Northumberland	Feb. 2, 1867
644	ROSS, ALEXANDER, Newcastle Wallsend Coal Company, Wallsend, New South Wales	Dec. 8, 1894
645	ROSS, HUGH, Croxdale Colliery Office, Durham	Aug. 6, 1892
646	ROSS, J. A. G., 9, Dean Street, Newcastle-upon-Tyne	July 2, 1872
647	ROTHWELL, R. P., 253, Broadway (P.O. Box 1833), New York, U.S.A.	March 5, 1870
648	ROUTLEDGE, W. H., Bedwelty House, Tredegar, Monmouth, South Wales	S. Oct. 7, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
649	ROWE, DANIEL, c/o Mrs. D. Rowe, Mount Ambrose, Redruth, Cornwall	June 21, 1894
650	ROWE, WILLIAM HENRY, 9, Earl Terrace, Douglas, Isle of Man	June 13, 1896
651	ROWLEY, WALTER, 20, Park Row, Leeds	Aug. 5, 1893
652	RUSSELL, ROBERT, Coltness Iron Works, Newmains, N.B.	Aug. 3, 1878
653	RUTHERFORD, W., South Derwent Colliery, Annfield Plain, Lintz Green	Oct. 3, 1874
654	SAINT, WILLIAM, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester	Oct. 10, 1896
655*	SAISE, WALTER, Giridih, E.I.R., Bengal, India	A.M. Nov. 3, 1877 M. Aug. 3, 1889
656	SAM, T. B. F., c/o F. and A. Swanzy, Cape Coast Castle, West Africa	Aug. 5, 1893
657	SAMBORNE, JOHN STUKELY PALMER, Timsbury House, Bath	Aug. 1, 1891
658	SANDEMAN, JOHN J., 73, Carleton Road, Tufnell Park, London, N.	Feb. 12, 1898
659	SANER, C. TAYLOR, Rietfontein A, Limited, Per Private Bag, Johannesburg, Transvaal	Oct. 13, 1894

			Date of Election and of Transfer.
660	SAUNDERS, DAVID WILLIAM ALBAN, Worcester Chambers, Swansea	A.M.	Feb 12, 1898
		M.	June 11, 1898
661	SAUNDERS, WILLIAM THOMAS, Ivydene, West Cross, R.S.O., near Swansea		June 12, 1897
662*	SAWYER, A. R., P.O. Box 2233, Johannesburg, Transvaal; and Hillhouse, Woking, Surrey	S.	Dec. 6, 1873
		A.M.	Aug. 2, 1879
		M.	June 8, 1889
663	SCHMITZ-DUMONT, G., Inspector of Mines, Barbeton, Transvaal		Dec. 11, 1897
664	SCHROLLER, WILLIAM, c/o Simon-Carves Bye-Product Coke Oven Construction and Working Company, Limited, 20, Mount Street, Manchester		Aug. 4, 1894
665	SCOTT, C. F., Grove Cottage, Leadgate, Co. Durham	S.	April 11, 1874
		M.	Aug. 4, 1877
666	SCOTT, ELGIN, Ropienka Oil Wells, Ropienka, Galicia, Austria		Aug. 4, 1894
667	SCOTT, ERNEST, Close Works, Newcastle-upon-Tyne		April 9, 1892
668	SCOTT, F. BOWES, c/o Bowes Scott and Company, 81, Cannon Street, London, E.C.		Dec. 14, 1895
669	SCOTT, JOSEPH, Ngahire, *via* Greymouth, New Zealand		Aug. 5, 1893
670	SCOTT, JOSEPH S., Trimdon Hall, Trimdon Grange, R.S.O., Co. Durham	S.	Nov. 19, 1881
		M.	April 9, 1892
671	SCOULAR, G., St. Bees, Cumberland		July 2, 1872
672	SECCOMBE, ALFRED F., 44, Hill Park Crescent, Plymouth		Dec. 9, 1893
673	SELBY, JOHN BASELEY, Leigh, Lancashire		April 25, 1896
674	SELKIRK, JOHN GUNSEN, Dalton-in-Furness		April 8, 1893
675	SETTLE, JOSEPH BURTON, Black Horse Hotel, Farnworth, near Bolton, Lancashire		Dec. 11, 1897
676	SEYMOUR, L. IRVING, P.O. Box 149, Johannesburg, Transvaal		Feb 14, 1891
677	SHAW, F. GEORGE		June 10, 1893
678*	SHAW, JAMES, Stanley House, Kent Town, Adelaide, South Australia		Dec. 12, 1896
679	SHAW, J. LESLIE, Somerset House, Whitehaven		Oct. 8, 1892
680	SHEAFER, A. WHITCOMB, Pottsville, Pennsylvania, U.S.A.		Aug. 4, 1894
681	SHIEL, JOHN, Framwellgate Colliery, Co. Durham		May 6, 1871
682	SHIPLEY, T. B., P.O. Box 97, Heidelberg, Transvaal. *Transactions* to be sent to c/o Andrew Reid and Company, Limited, Newcastle-upon-Tyne	A.M.	Aug. 2, 1884
		M.	Aug. 3, 1889
683	SHORE, WILLIAM MARTIN, Kaitangata Railway and Coal Company's Collieries, Otago, New Zealand	A.M.	April 13, 1889
		M.	Aug. 3, 1889
684	SHOTTON, JOHN, Ottoman Railway Company, Smyrna, Asia Minor		Oct. 14, 1893
685	SHUTE, C. A., High Terrace, Darlington		April 11, 1874
686	SIBOLD, C. W., Public Works Department, Soane Circle, Arrah, Bengal, India		Dec. 9, 1893
687	SIMON, FRANK, P.O. Box 2986, Johannesburg, Transvaal		Dec. 14, 1895
688	SIMPSON, C. L., Engine Works, Grosvenor Road, Pimlico, London		April 8, 1893
689	SIMPSON, F. L. G., Mohpani Coal Mines, Gadawarra, C.P., India	A.M.	Dec. 13, 1884
		M.	Aug. 3, 1889
690	SIMPSON, F. R., Hedgefield House, Blaydon-upon-Tyne (*Member of Council*)	S.	Aug. 4, 1883
		M.	Aug. 1, 1891
691	SIMPSON, GILBERT PITCAIRN, 3, Cornwall Terrace, Regent's Park, London, N.W.		Oct. 10, 1896
692	SIMPSON, J., Heworth Colliery, Felling, R.S.O., Co. Durham (*Member of Council*)	S.	Dec. 6, 1866
		M.	Aug. 1, 1868
693	SIMPSON, J. B., Bradley Hall, Wylam-upon-Tyne (PAST-PRESIDENT, *Member of Council*)		Oct. 4, 1860
694	SLADDEN, HARRY, P.O. Box 2844, 6, Barnato Buildings, Johannesburg, Transvaal		Nov. 24, 1894
695	SLINN, T., 19, Edwards Road, Whitley, Northumberland		July 2, 1872
696	SLOOTEN, WILLIAM VAN, 52, Sidney Place, Brooklyn, New York, U.S.A.		Feb. 13, 1897
697	SMAILES, JNO., Hebburn Colliery, Newcastle-upon-Tyne		June 8, 1895
698	SMART, A., c/o Frazer and Chalmers, Limited, Erith, Kent		Feb. 10, 1894

			Date of Election and of Transfer.
699	SMITH, EUSTACE, Newcastle-upon-Tyne	A.M.	June 11, 1887
		M.	Aug. 3, 1889
700*	SMITH, R. CLIFFORD, Ashford Hall, Bakewell		Dec. 5, 1874
701	SOPWITH, A., Cannock Chase Collieries, near Walsall ...		Aug. 6, 1863
702	SOUTHERN, E. O., Ashington Colliery, near Morpeth ...	S.	Dec. 5, 1874
		A.M.	Aug. 1, 1885
		M.	June 8, 1889
703	SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff		Aug. 3, 1865
704	SOUTHWORTH, THOMAS, Hindley Green Collieries, near Wigan		May 2, 1874
705	SPARGO, EDMUND, 3, Cable Street, Liverpool		June 10, 1893
706	SPARKES, J. S., 15, Northcote Street, Cardiff		April 9, 1892
707	SPENCE, R. F., Backworth, R.S.O., Northumberland ...	S.	Nov. 2, 1878
		A.M.	Aug. 2, 1884
		M.	Aug. 4, 1889
708	SPENCER, FRANCIS H., Bonanza Gold Mining Company, P.O. Box 149, Johannesburg, Transvaal		Dec. 13, 1890
709	SPENCER, JOHN, Westgate Road, Newcastle-upon-Tyne .		Dec. 4, 1869
710	SPENCER, JOHN W., Newburn, near Newcastle-upon-Tyne...		May 4, 1878
711	SPENCER, T., Ryton, near Newcastle-upon-Tyne		Dec. 6, 1866
712	SQUIRE, J. B., The Wynd, Streatham Park, London, S.W.		June 8, 1895
713	STANLEY, JAMES, 3, Chancery Chambers, Coolgardie, Western Australia		Dec. 12, 1896
714	STANSFELD, HAROLD SINCLAIR, High Hazels Colliery, Darnall, Sheffield	A.M.	Oct. 13, 1888
		M.	Aug. 3, 1889
715	STANTON, JOHN, 11 and 13, William Street, New York, U.S.A.		June 8, 1895
716	STEAVENSON, A. L., Durham (PAST-PRESIDENT, *Member of Council*)		Dec. 6, 1855
717	STEAVENSON, C. H., Redheugh Colliery, Gateshead-upon-Tyne	S.	April 14, 1883
		A.	Aug. 1, 1891
		M.	Aug. 3, 1895
718	STEELE, WARDLE		April 27, 1895
719	STEPHENSON, G. R., Ben Braich, Tilehurst Road, Reading		Oct. 4, 1860
720	STEVENS, A. J., Uskside Iron Works, Newport, Monmouthshire		April 8, 1893
721	STEVENS, JAMES, 9, Fenchurch Avenue, London, E.C. ...		Feb. 14, 1885
722	STEWART, WILLIAM, Tillery Collieries, Abertillery, Monmouthshire		June 8, 1895
723	STOBART, F., Biddick Hall, Fence Houses	S.	Aug. 2, 1873
		A.M.	Aug. 5, 1882
		M.	June 8, 1889
724	STOBART, H. T., Wearmouth Colliery, Sunderland	S.	Oct. 2, 1880
		A.M.	Aug. 4, 1888
		M.	Aug. 3, 1889
725	STOBART, W., Pepper Arden, Northallerton		July 12, 1872
726	STOBART, WILLIAM RYDER, Etherley Lodge, Darlington ...		Oct. 11, 1890
727	STOIBER, EDWARD G., P.O. Box 129, Silverton, Colorado, U.S.A....	A.M.	Oct. 12, 1895
		M.	Feb. 15, 1896
728	STOKER, ARTHUR P., Birtley, near Chester-le-Street ..	S.	Oct. 6, 1877
		A.M.	Aug. 1, 1885
		M.	Aug. 3, 1889
729	STONE, ARTHUR, Heath Villas, Hindley, Wigan		June 13, 1896
730	STRAKER, J. H., Howden Dene, Corbridge-upon-Tyne ...		Oct. 3, 1874
731	STREATFIELD, HUGH S., Ryhope, near Sunderland	A.M.	June 8, 1889
		M.	Aug. 3, 1889
732	STUART, DONALD M. D., Redland, Bristol		June 8, 1895
733	SULLIVAN, C. D., Bonang, Delegate, New South Wales ..		Feb. 9, 1895
734	SWALLOW, J., Catchgate, Annfield Plain, R.S.O., Co. Durham		May 2, 1874
735	SWALLOW, R. T., Simonside House, Simonside, South Shields		Feb. 5, 1863
736	SWAN, H. F., North Jesmond, Newcastle-upon-Tyne ...		Sept. 2, 1871
737	SWAN, J. G., Upsall Hall, near Middlesbrough		Sept. 2, 1871

		Date of Election and of Transfer.
738	Tate, Simon, Trimdon Grange Colliery, Co. Durham ...	Sept. 11, 1875
739	Tattley, William, Taupiri Extended Coal Mining Company, Limited, Huntly, Waikato, New Zealand	Aug. 3, 1895
740	Tatum, Lawrence W., c/o Dwight, Furness and Company, San Luis de la Paz, Guanajuato, Mexico...	A.M. Aug. 7, 1897 M. Dec. 11, 1897
741	Taylor, Hugh, East Holywell Office, Quay, Newcastle-upon-Tyne	Sept. 5, 1856
742	Taylor, T., Quay, Newcastle-upon-Tyne	July 2, 1872
743	Teasdale, Thomas, Middridge, *via* Heighington, R.S.O. ...	April 9, 1892
744	Telford, W. H., Hedley Hope Collieries, Tow Law, R.S.O., Co. Durham	S. Oct. 3, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
745	Thackthwaite, Thomas Michael, Beechfield, Farnham Royal, Bucks....	Oct. 10, 1896
746	Thomas, Arthur, The British Gold Mines of Mexico, Limited, Mina "El Carmen," El Oro, Tultenango, Estado de Mexico	Aug. 7, 1897
747	Thomas, Edward, The Shieling, Auburn, Sydney, New South Wales	Aug. 4, 1894
748	Thomas, J. J., Newnham Cottage, Kendal	June 21, 1894
749	Thomlinson, William, Seaton Carew, R.S.O.	April 25, 1896
750	Thompson, Charles Lacy, Farlam Hall, Brampton Junction, Cumberland	A.M. Feb. 10, 1883 M. Aug. 3, 1889
751	Thompson, Francis William, 15, Wood Street, Bolton, Lancashire	June 8, 1895
752	Thompson, John G., Bamfurlong, Wigan	June 8, 1895
753	Thompson, W., 58, New Broad Street, London, E.C. ...	Aug. 4, 1888
754	Thomson, John, Eston Mines, by Middlesbrough	April 7, 1877
755	Thomson, Joseph F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
756	Tinker, J. J., Hyde, Manchester	April 9, 1892
757	Todd, John T., Blackwell Collieries, Alfreton	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
758	Tonkin, J. J., Linares, Provincia de Jaen, Spain	Oct. 14, 1893
759	Touzeau, E. M., Leadenhall Buildings, Leadenhall Street, London, E.C.	Aug. 6, 1892
760	Treadwell, G. A., Nevada City, California, U.S.A. ...	Aug. 3, 1895
761	Trelease, W. Henwood, Pesterena United Gold Mining Company, Limited, Pestarena, Vall Anzasca, Novara, Italy	April 8, 1893
762	Tulip, Samuel, Bunker Hill, Fence Houses	June 12, 1897
763	Turnbull, John James, East Indian Coal Company, Limited, Jherria P.O., District Manbhoom, Bengal, India	Feb. 12, 1898
764*	Tyers, John E., Singareni Collieries, c/o The Hyderabad Deccan Company, Limited, Secunderabad, Deccan, East India	A.M. Dec. 10, 1877 M. Aug. 3, 1889
765	Tyzack, David, Bellingham, Northumberland	Feb. 14, 1874
766	Upton, Prescott, P.O. Box 1026, Johannesburg, Transvaal	June 12, 1897
767	Varty, Thomas, Skelton Park Mines, Skelton, R.S.O., Cleveland	Feb. 12, 1887
768	Vaughan, Cedric, Hodbarrow Iron Ore Mines, Millom, Cumberland	Dec. 10, 1892
769	Vaughan, John, Balaclava House, Dowlais, Glamorganshire	Feb. 12, 1898
770	Vautin, Claude, 66, Old Broad Street, London, E.C. ...	July 14, 1896
771	Veasey, T. F., 5, Copthall Buildings, London, E.C. ...	Oct. 12, 1895
772	Veasy, Harvey C., Burrakur Coal Company, Limited, Barakar, Bengal, India	June 21, 1894
773	Verschoyle, William Denham, Alpha Gold Mining Company, Westland, New Zealand	Dec. 11, 1897
774	Vezin, Henry A., P.O. Box 256, Denver, Colorado, U.S.A.	June 21, 1894
775	Vitanoff, George N., Sophia, Bulgaria	A.M. April 22, 1882 M. Aug. 3, 1889

		Date of Election and of Transfer.
776	VIVIAN, JOHN, Vivian's Boring and Exploration Company, Limited, 42, Lowther Street, Whitehaven	March 3, 1877
777	WADDLE, HUGH, Llanmore Iron Works, Llanelly, South Wales	Dec. 13, 1890
778	WADHAM, E., Millwood, Dalton-in-Furness	Dec. 7, 1867
779	WAGNER, JOHN R., The Cross Creek Coal Company, Drifton, Luzerne County, Pennsylvania, U.S.A.	Oct. 9, 1897
780	WALES, H. T., Western Mail Chambers, Cardiff	Feb. 11, 1893
781	WALKER, HENRY BLAIR, Die Rietfontein Colliery, Springs, Johannesburg, Transvaal	Oct. 9, 1897
782	WALKER, J. S., Pagefield Iron Works, Wigan, Lancashire	Dec. 4, 1869
783	WALKER, SYDNEY FERRIS, Cardiff Electrical Works, Severn Road, Cardiff	June 11, 1898
784	WALKER, THOMAS A., Pagefield Iron Works, Wigan, Lancashire	June 8, 1895
785	WALKER, W., Hawthorns, Saltburn-by-the-Sea	March 5, 1870
786	WALKER, WILLIAM, Jun., H.M. Inspector of Mines, Durham	Aug. 3, 1889
787	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
788	WALL, HENRY, Rowbottom Square, Wallgate, Wigan ...	June 8, 1895
789	WALLACE, HENRY, Trench Hall, Gateshead-upon-Tyne ...	Nov. 2, 1872
790	WALLWORK, JESSE, Bolton Road, Atherton, Lancashire ...	Feb. 9, 1895
791	WALSH, G. PATON, 564, Heirengracht, Amsterdam, Holland	Nov. 24, 1894
792	WALTON, J. COULTHARD, Writhlington Colliery, Radstock, *via* Bath	S. Nov. 7, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
793	WALTON, THOMAS, Habergham Colliery, Burnley	Aug. 3, 1895
794	WARD, A. H., c/o Bengal Coal Company, Limited, Calcutta, India	April 14, 1894
795	WARD, H., Rodbaston Hall, near Penkridge, Stafford ...	March 6, 1862
796*	WARD, T. H., Birwadih Bungalow, Giridih, E.I.R., Bengal, India	A.M. Aug. 5, 1882 M. Aug. 3, 1889
797	WATKYN-THOMAS, W., Workington	A.M. Feb. 10, 1883 M. Aug. 3, 1889
798	WATSON, EDWARD South Pelaw Colliery, Chester-le-Street	S. Feb. 13, 1892 M. Aug. 4, 1894
799	WATSON, THOMAS, Trimdon Colliery, Trimdon Grange ...	Oct. 11, 1890
800	WATTS, J. WHIDBOURNE, General Manager, United Ivy Gold Mining Company, Limited, Barberton, Transvaal	Dec. 12, 1896
801	WATTS, WILLIAM, Sheffield Corporation Water Department, Little Don Valley Works, Engineer's Office, Langsett, near Penistone	June 13, 1896
802	WEBSTER, ALFRED EDWARD, 30, George Street, Worksop, Notts.	June 12, 1897
803	WEBSTER, H. INGHAM, Mainsforth Hall, Ferryhill, S.O., Co. Durham	A.M. April 14, 1883 M. Aug. 3, 1889
804	WEBSTER, JOHN, 29, Macaulay Road, Clapham, London, S.W.	A.M. July 14, 1896 M. Oct. 10, 1896
805	WEEKS, J. G., Bedlington, R.S.O., Northumberland (VICE-PRESIDENT, *Member of Council*)	Feb. 4, 1865
806	WEEKS, R. L., Willington, Co. Durham	A.M. June 10, 1882 M. Aug. 3, 1889
807	WELCH, DAVID WILLIAM, Dixie Gold Mines, Limited, Black Flag, Western Australia	Dec. 12, 1896
808	WESTERN, C. R., Broadway Chambers, Westminster, London, S.W....	June 10, 1893
809	WESTMACOTT, P. G. B., Benwell Hill, Newcastle-upon-Tyne	June 2, 1866
810	WHALLEY, FREDERICK HERBERT, Queen Street, Auckland, New Zealand	Oct. 9, 1897
811	WHITE, C. E., Wellington Terrace, South Shields ...	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. Aug. 3, 1889
812	WHITE, H., Walker Colliery, Newcastle-upon-Tyne ...	S. March 2, 1867 M. Aug. 5, 1871
813	WHITE, J. F., 15, Wentworth Street, Wakefield	S. July 2, 1872 M. Aug. 2, 1873

		Date of Election and of Transfer.
814	WHITE, I. W. H., 1, Albion Place, Leeds	Sept. 2, 1876
815	WHITEHEAD, JOHN JAMES, Bracklyn, Stretford, Manchester	S. Dec. 12, 1891
		M. Feb. 15, 1896
816	WHITELAW, JOHN, 118, George Street, Edinburgh	Feb. 5, 1870
817	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington	Dec. 5, 1868
818	WIGHT, EDWARD S., Taupiri Reserve Colliery, Kimihia, Auckland, New Zealand	A.M. Dec. 12, 1885 M. Aug. 3, 1889
819	WIGHT, W. H., Cowpen Colliery, Blyth	Feb. 3, 1877
820	WILCOX, HENRY, Miners' Safety Explosive Works, Stanford-le-Hope, Essex	June 8, 1895
821	WILKINS, WILLIAM GLYDE, Westinghouse Building, Pittsburg, Pennsylvania, U.S.A.	Dec. 11, 1897
822*	WILKINSON, WILLIAM FISCHER, Rand Club, Johannesburg, Transvaal	Oct. 10, 1896
823	WILLIAMS, ERNEST, c/o Bewick, Moreing and Company, A.M.P. Buildings, St. George's Terrace, Perth, Western Australia	Oct. 10, 1891
824	WILLIAMS, GARDNER F., De Beers Consolidated Mines, Limited, Kimberley, South Africa	Oct. 12, 1895
825	WILLIAMS, H. J. CARNEGIE, c/o J. McDonald, 43, Threadneedle Street, London, E.C.	Oct. 12, 1895
826	WILLIAMS, LUKE, Curtin-Davis Proprietary Mine, Ringville, West Coast, Tasmania	April 10, 1897
827	WILLIAMS, RICHARD, The Johnsons Reef Gold Mines Company, California Gulley, Bendigo, Victoria, Australia...	A.M. June 13, 1896 M. Aug. 1, 1896
828	WILLIAMS, ROBERT, 30, Clements Lane, Lombard Street, London, E.C.	June 13, 1896
829	WILLIAMS, SAMUEL HERBERT, Golden Cement Claims, Limited, Kanowna, Western Australia	July 14, 1896
830	WILLIAMSON, W. DUNCAN, c/o John Williamson, Cumberland Cyanide Works, Cumberland, North Queensland	April 27, 1895
831	WILSON, ARCHIBALD LAURENCE, Glenoven House, Westcombe Hill, Blackheath, London	A.M. June 12, 1897 M. April 2, 1898
832	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton	Nov. 5, 1852
833	WILSON, JOSEPH R., 1001, Chesnut Street, Philadelphia, U.S.A....	Oct. 12, 1895
834	WILSON, LLOYD, Flimby Colliery, Maryport	Jan. 19, 1895
835	WILSON, P. O., P.O. Box 57, Klerksdorp, South Africa ...	Dec. 9, 1893
836	WILSON, W. B., Thornley Colliery, Thornley, R.S.O., Co. Durham	Feb. 6, 1869
837	WINCHELL, HORACE V., Butte, Montana, U.S.A.	Nov. 24, 1894
838	WINSTANLEY, ROBERT, 28, Deansgate, Manchester	Sept. 7, 1878
839	WOOD, C. L., Freeland, Forgandenny, Perthshire	Aug. 3, 1854
840	WOOD, ERNEST SEYMOUR, c/o The Bengal Coal Company, Old Court House Street, Calcutta, India	Oct. 10, 1891
841	WOOD, JOHN, Coxhoe Hall, Coxhoe, R.S.O., Co. Durham ...	S. June 8, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
842*	WOOD, SIR LINDSAY, Bart., The Hermitage, Chester-le-Street (PAST-PRESIDENT, *Member of Council*)	Oct. 1, 1857
843	WOOD, ROBERT ARNA, c/o N. R. Griffith, 18, Queen Victoria Street, London, E.C.	April 10, 1897
844	WOOD, THOMAS, North Hetton Colliery Office, Moorsley, Hetton-le-Hole, R.S.O., Co. Durham	S. Sept. 3, 1870 M. Aug. 5, 1871
845	WOOD, W. H., Coxhoe Hall, Coxhoe, R.S.O., Co. Durham...	Aug. 6, 1857
846	WOOD, W. O., South Hetton, Sunderland (RETIRING VICE-PRESIDENT, *Member of Council*)	Nov. 7, 1863
847	WOODBURNE, T. J., De Beers Consolidated Mining Company, Limited, Kimberley, South Africa	Feb. 10, 1894
848	WOODWARD, HARRY PAGE, 59, Irwin Street, Perth, Western Australia. All *Transactions*, Circulars, etc., to be sent to 129, Beaufort Street, Chelsea, London, S.W. ...	A.M. June 10, 1893 M. Oct. 10, 1896
849	WOOLCOCK, J. H., 49, Lowther Street, Whitehaven ...	June 10, 1893
850	WORMALD, C. F., Mayfield Villa, Saltwell, Gateshead-upon-Tyne	A.M. Dec. 8, 1883 M. Aug. 3, 1889

		Date of Election and of Transfer.
851	WRIGHTSON, T., Stockton-upon-Tees	Sept. 13, 1873
852	WYNNE, T. TRAFFORD, c/o Touzeau and Janson, A.M.P. Buildings, 216, Queen Street (P.O. Box 530), Auckland, New Zealand	Oct. 12, 1895
853	YEOMAN, THOMAS P., Manager, Bengal Coal Company's Collieries, Laikdih, *via* Barakar, E.I.R., Bengal, India	S. Feb. 14, 1885 A. Aug. 4, 1894 M. Oct. 13, 1894
854	YOUNG, HENRY WILLIAM, Greymouth, New Zealand ...	Dec. 12, 1896
855	YOUNG, JAMES, 19, Wentworth Place, Newcastle-upon-Tyne	Oct. 9, 1897
856	YOUNG, JOHN A., 3, Fountain Avenue, Gateshead-upon-Tyne	A.M. Dec. 10, 1887 M. Aug. 3, 1889
857	YOUNG, JOHN HUNTLEY, Wearmouth Colliery, Sunderland	June 21, 1894
858	YOUNG, WILLIAM ALEXANDER, 16, St. Helen's Place, London, E.C.	Feb. 13, 1897
859	ZUMBULOGLON, G. C., Mahmoudie-Han, Stamboul, Turkey	S. Feb. 14, 1891 A. Aug. 4, 1894 M. Aug. 3, 1895

ASSOCIATE MEMBERS.

Marked * have paid life composition.

		Date of Election and of Transfer.
1	AINSWORTH, H. S., "Belvedere," Marine Terrace, Geraldton, Western Australia	Feb. 15, 1896
2	ARCHIBALD, JOHN WILSON, Coolgardie, Western Australia ...	Feb. 15, 1896
3	ARMSTRONG, ALBERT MONTAGUE, 3 and 4, Crooked Lane, King William Street, London, E.C.	Aug. 7, 1897
4	ARMSTRONG, J. H., St. Nicholas' Chambers, Newcastle-upon-Tyne	Aug. 1, 1885
5	ARMSTRONG, T. J., Hawthorn Terrace, Newcastle-upon-Tyne ...	Feb. 10, 1883
6	ATKINSON, G. B., Prudential Assurance Buildings, Mosley Street, Newcastle-upon-Tyne	Nov. 5, 1892
7	AUDUS, T., Mineral Traffic Manager, North Eastern Railway, Newcastle-upon-Tyne	Aug. 7, 1880
8	BANKS, CHARLES JOHN, Westwood, Washington, R.S.O., Co. Durham	Feb. 12, 1898
9	BANYER, B. R., Kapunda, South Australia	Oct. 13, 1894
10*	BELL, HUGH, Middlesbrough-upon-Tees	Dec. 9, 1882
11	BENEKÉ, G.	Feb. 9, 1895
12	BIGGE, EDWARD ELLISON, General Mining Association, Dashwood House, 9, New Broad Street, London, E.C. *Transactions*, etc., to be sent to R. H. Brown, Sydney Mines, Cape Breton, Nova Scotia	Aug. 1, 1891
13	BLENKIRON, J. ERNEST, Zomba, British Central Africa	Feb. 11, 1893
14	BLUE, ARCHIBALD, Bureau of Mines, Toronto, Ontario, Canada...	Feb. 10, 1894
15	BREE, JOHN, Bleak House, Litlington, near Royston, Herts. ...	June 13, 1896
16	BURDON, A. E., Hartford House, Cramlington, Northumberland	Feb. 10, 1883
17	CAPELL, REV. G. M., Passenham Rectory, Stony Stratford ...	Oct. 8, 1892
18*	CARR, WILLIAM COCHRAN, 91, Jesmond Road, Newcastle-upon-Tyne	Oct. 11, 1890
19	CHAPLIN, GEORGE P., Ouspensky Mines, Kotschar, Orenburg, Russia	S. Feb. 15, 1896 A.M. Oct. 9, 1897
20	CHAPMAN, C. W., The Australian Smelting Company, Limited, 39, Queen Street, Melbourne, Australia	Feb. 15, 1896
21*	CHEWINGS, DR. CHARLES, Albany, Western Australia	April 25, 1896
22	CLELAND, E. DAVENPORT, Bayley Street, Coolgardie, Western Australia	June 13, 1896
23	COCHRANE, RALPH D., Hetton Colliery Offices, Fence Houses ...	June 1, 1878
24	COCKBURN, W. C., 1, St. Nicholas' Buildings, Newcastle-upon-Tyne	Oct. 8, 1887

Date of Election and of Transfer.

25 Colquhoun, A. J., School of Mines, Vancouver, British Columbia ... July 14, 1896
26 Cooper, E. F. X., P.O. Box 66, Pretoria, South Africa ... Feb. 15, 1896
27 Cooper, R. W., Newcastle-upon-Tyne ... Sept. 4, 1880
28 Cory, Clifford J., c/o Cory Brothers and Company, Limited, Cardiff ... Dec. 11, 1897
29 Crosby, A. ... Aug. 7, 1897

30 Dickson, Berkly Gillespie ... Oct. 9, 1897
31 Duncan, G. T., 96, Brighton Grove, Newcastle-upon-Tyne ... Aug. 5, 1893

32 Eccles, Edward, King Street, Newcastle-upon-Tyne ... Oct. 13, 1894
33 Edwards, F. H., Forth House, Bewick Street, Newcastle-upon-Tyne ... June 11, 1887
34 Ellam, Albert Spencer, 20, Bucklersbury, London, E.C. ... April 25, 1896

35 Ferguson, C. A., 41, Lovaine Place, Newcastle-upon-Tyne ... July 14, 1896
36 Foster, T. J., Coal Exchange, Scranton, Pennsylvania, U.S.A. ... Dec. 12, 1891

37 Goodland, Gillmore, Ravenswood, Queensland, Australia ... July 14, 1896
38 Graham, John, Findon Cottage, near Durham ... Oct. 9, 1897
39 Griffin, Noel, Geelong Gold Mines, Gwanda, Matabeleland, South Africa ... Feb. 13, 1897
40 Gue, T. R., P.O. Box 520, Halifax, Nova Scotia ... Feb. 15, 1896
41 Guthrie, Reginald, Neville Hall, Newcastle-upon-Tyne (Treasurer, *Member of Council*) ... Aug. 4, 1888
42 Gwyn, A. E. W., 114a, Queen Victoria Street, London, E.C. ... Aug. 4, 1894

43 Hardy, Thomas Edward, Kalgoorlie, Western Australia ... April 10, 1897
44 Harris, David ... June 12, 1897
45 Harvey, Francis G., Plu Le Desir, Canal No. 1, Demerara, British Guiana ... July 14, 1896
46 Hedley, J. Hunt, John Street, Sunderland ... June 13, 1891
47 Heeley, George, 61, Kyle Park, Uddingston, near Glasgow ... Dec. 14, 1895
48 Henderson, C. W. C., The Riding, Hexham ... Dec. 9, 1882
49 Henzell, Robert, Prudential Buildings, Mosley Street, Newcastle-upon-Tyne ... April 11, 1891
50 Heyworth, Colonel Lawrence, Chadacre Hall, Bury St. Edmunds, Suffolk ... Dec. 14, 1895
51 Hodgetts, Arthur, 300, Rookery Road, Handsworth, Birmingham ... Oct. 9, 1897
52 Hodgson, Albert, c/o F. G. Borissow and Company, 24, Charles Street, Bradford ... Feb. 13, 1897
53 Holland, Williamson, 65, William Street, Heywood, Lancashire ... Feb. 13, 1897
54 Holliday, Henry, Consett Iron Company, Limited, Blackhill, Co. Durham ... Feb. 12, 1898
55 Hopper, J. I., Wire Rope Works, Thornaby-upon-Tees ... Dec. 8, 1888
56 Humphreys-Davies, G., 8, Laurence Pountney Hill, Cannon Street, London, E.C. ... Oct. 8, 1892
57 Hunter, C. E., Selaby Park, Darlington ... April 27, 1895

58 Irvine, J. R., Hendon Ropery, Sunderland ... Dec. 10, 1887

59 James, Henry M., Colliery Office, Whitehaven ... June 10, 1893
60 Jeffrey, Joseph Andrew, c/o The Jeffrey Manufacturing Company, Columbus, Ohio, U.S.A. ... Dec. 11, 1897
61 Jobson, Edward, 5, Bath Terrace, Tynemouth ... Oct. 9, 1897
62* Joicey, James John, Holyrood, Laurie Park Road, Sydenham, London, S.E. ... Oct. 10, 1891

63 Kirkup, Frederic O., Langley Park, Durham ... S. April 9, 1892
A.M. April 25, 1896
64 Krohn, H. A., 103, Cannon Street, London, E.C. ... Oct. 14, 1893

		Date of Election and of Transfer.
65	LAMB, EDMUND GEORGE, Old Lodge, Salisbury	Feb. 12, 1898
66	LARSEN, A., 10, Welbeck Mansions, Inglewood Road, West Hampstead, London, N.W.	April 27, 1895
67	LAWRANCE, DAVID H., c/o Cuthbert and Company, P.O. Box 326, Vancouver, British Columbia	Feb. 12, 1898
68	LOEVY, J., P.O. Box 778, Johannesburg, Transvaal	June 13, 1896
69	LUMSDEN, JOHN ALDER, Umaria Colliery, Umaria, C.P., India...	Dec. 11, 1897
70	MARSHALL, P., College and Grammar School, Auckland, New Zealand	June 12, 1897
71	MINARD, FREDERICK HORACE, 409, Equitable Building, Denver, Colorado, U.S.A.	Dec. 11, 1887
72	MONCKTON, G. F., School of Mines, Vancouver, British Columbia	July 14, 1896
73	NASON, FRANK L., 5, Union Street, New Brunswick, New Jersey	Aug. 4, 1894
74	PALMER, A. M., 1, Jesmond High Terrace, Newcastle-upon-Tyne. *Transactions* to be sent to the Anglo-American Club, Freiburg, Saxony, Germany	Nov. 24, 1894
75	PERKINS, CHARLES, Middleton Hall, Belford, Northumberland ...	Aug. 6, 1892
76*	PICKUP, P. W. D., Rishton Colliery, Rishton, near Blackburn ...	Feb. 12, 1898
77	PRINGLE, JOHN, Chinese Engineering and Mining Company, Tong Shan, Tientsin, North China	Feb. 13, 1897
78*	PROCTOR, JOHN H., 22, Hawthorn Terrace, Newcastle-upon-Tyne	June 8, 1889
79	RICHTER, F., Osborne Villas, Newcastle-upon-Tyne	Oct. 10, 1891
80	RIDLEY, J. CARTMELL, 3, Summerhill Grove, Newcastle-upon-Tyne	Feb. 11, 1893
81	RIDLEY, SIR MATTHEW W., Bart., Blagdon, Northumberland ..	Feb. 10, 1883
82	RITSON, J. RIDLEY, Burnhope Colliery, Lanchester ... S.	April 11, 1891
	A.M.	Aug. 3, 1895
83	ROBERTS, WILLIAM MURRAY, P.O. Box 413, Johannesburg, Transvaal	Oct. 9, 1897
84	ROBINSON, JOHN WALTON, 6, Gladstone Terrace, Gateshead-upon-Tyne	Dec. 12, 1896
85	ROBSON, HENRY NAUNTON, Post Office, Yokohama, Japan ...	Dec. 12, 1896
86	ROGERSON, JOHN E., Oswald House, Durham	June 8, 1895
87	SAUNDERS, G. B., Messrs. Saunders, Todd and Company, Maritime Buildings, King Street, Newcastle-upon-Tyne ...	Jan. 19, 1895
88	SCOTT, JOHN OLIVER, The Glebe, Riding Mill-upon-Tyne ...	Dec. 11, 1897
89	SHAW, SAVILLE, Durham College of Science, Newcastle-upon-Tyne	April 13, 1889
90	SHERLAW, JAMES LINN, Coolgardie Gold Syndicate, Coolgardie, Western Australia	Aug. 1, 1896
91	SJÖGREN, HJ., Osmo-Nyntes, Sweden...	April 25, 1896
92	SMITH, C. A., 20, Alexandra Place, Newcastle-upon-Tyne ...	Dec. 8, 1894
93	SMITH, PERCY WEBSTER, Crichtons, Romford	Feb. 13, 1897
94	SNOWBALL, FRANCIS JOHN, Seaton Burn House, Dudley, Northumberland	Dec. 12, 1891
95	STEWART, SAMUEL, 16, Great George Street, Westminster, London, S.W.; and Parkhurst, Park Road, Wallington, Surrey	Feb. 12, 1898
96	STOKES, H. G., Silver Spur Silver Mines, Texas, *via* Stanthorpe, Queensland, Australia	Dec. 11, 1897
97	STRANGE, HAROLD FAIRBROTHER, Johannesburg Consolidated Investment Company, Limited, P.O. Box 590, Johannesburg, Transvaal	Dec. 11, 1897
98	SWINBURNE, U. P., c/o R. Chamberlain, 39, Cadogan Square, London, S.W.	Aug. 4, 1894
99	TATTLEY, ERNEST WILLIAM, Taupiri Extended Coal Mining Company, Limited, Mine Manager's Office, Waikato, Auckland, New Zealand	June 12, 1897
100	THOM, JOHN, Canal Works, Patricroft, near Manchester ...	June 8, 1895
101	TODD, JAMES, Elvet Bridge, Durham...	Aug. 6, 1892

		Date of Election and of Transfer.
102	TUNNINGTON, ALBERT, Mawsons Reward Company, Dundas, Western Australia	Oct. 9, 1897
103	TURNER, BASIL WILLIAM, 40, Collins Street, Annandale, Sydney, New South Wales	Feb. 13, 1897
104	WALL, G. YOUNG, Halmote Court Office, New Exchequer Building, Durham...	Nov. 24, 1894
105	WALMESLEY, OSWALD, 2, Stone Buildings, Lincoln's Inn, London, W.C.	June 8, 1895
106	WARREN, HENRY B., Vancouver, British Columbia	June 12, 1897
107	WATSON, ARTHUR, Burnopfield, Co. Durham	Oct. 13, 1894
108	WEATHERBURN, JOHN, Meynell House, Rowlands Gill, Burnopfield, R.S.O., Co. Durham	Oct. 13, 1894
109	WEHNER, FRED C., c/o Senor Don Carlos Wagner, Arequipa, Peru, South America	Feb. 13, 1897
110	WESLEY, W. H., Sen., The Anchor Tin Mine, Limited, Lottah, Tasmania	Dec 11, 1897
111	WHITEHEAD, THOMAS, Brindle Lodge, near Preston, Lancashire	June 12, 1897
112	WILLS, LOUIS. Coolgardie, Western Australia	Aug. 1, 1896
113	WILSON, ARTHUR P., Mansion House Chambers, Queen Victoria Street, London, E.C.	Aug. 3, 1889
114*	WOOD, ARTHUR NICHOLAS LINDSAY, The Hermitage, Chester-le-Street	July 14, 1896
115	WOOD, E. P.	Aug. 3, 1895

ASSOCIATES.

		Date of Election and of Transfer.
1	BAINBRIDGE, JAMES	June 10, 1893
2	BAKER, GEORGE, Bedlington Colliery, Bedlington, R.S.O.	Aug. 3, 1895
3	BARRASS, M., Tudhoe Colliery, Spennymoor	S. Feb. 9, 1884 A. Aug. 1, 1891
4	BATTEY, THOMAS, Percy Terrace, Backworth Colliery ...	Oct. 13, 1894
5	BELL, JOHN, Wardley Colliery, Newcastle-upon-Tyne ...	Feb. 8, 1890
6	BELL, W. RALPH, Wearmouth Colliery, Sunderland ...	Oct. 13, 1894
7	BERRY, THOMAS, 1, Middleton, Swalwell, R.S.O.	Nov. 5, 1892
8	BEWICK, GEORGE, Dudley Colliery, Northumberland ...	April 10, 1897
9	BOLAM, J. T., The View, Beamish, Chester-le-Street ...	Oct. 14, 1893
10	BOWES, THOMAS, Pontop House, Annfield Plain, R.S.O. ...	Feb. 13, 1892
11	BOWMAN, FRANK, Auckland Park Colliery, near Bishop Auckland	June 8, 1895
12	BROWN, JOHN	Feb. 15, 1896
13	BROWN, ROBERT O., Throckley Colliery, near Newcastle-upon-Tyne	S. Oct. 8, 1892 A. Aug. 3, 1895
14	CARROLL, JOHN, 14, Garden Street, Newfield, Willington, Co. Durham	Feb. 12, 1898
15	CLARK, THOMAS, Dipton Colliery, Lintz Green Station ...	Oct. 11, 1890
16	CLIFFORD, E. HERBERT, c/o W. Y. Campbell, P.O. Box 357, Johannesburg, Transvaal	S. Oct. 13, 1894 A. Aug. 6, 1898
17	CLOUGH, JOHN, 1, Melton Terrace, Seaton Delaval Colliery, R.S.O., Northumberland	Feb. 13, 1897
18	COCKBURN, EDMUND, 28, Gerrie Street, Boosbeck Skelton-in-Cleveland, Yorkshire	Dec. 11, 1897
19	COCKBURN, EVAN, Page Bank Colliery, *via* Spennymoor, Co. Durham	Aug. 5, 1893
20	COWELL, J. STANLEY, Hylton Colliery, near Sunderland ...	Oct. 13, 1894
21	COWX, H. F., Thornley Collieries, *via* Trimdon Grange, R.S.O.	April 14, 1894
22	CROWN, WILLIAM, 39, Fifth Row, Ashington, Morpeth ...	April 14, 1894
23	DAVIS, JAMES E., South Medolmsley Colliery, Dipton, R.S.O., Co. Durham	Feb. 12, 1898
24	DAVISON, FRANCIS, 58, Hedley Hill Terrace, Waterhouses, Co. Durham	Feb. 12, 1898

		Date of Election and of Transfer.
25	DAVISON, MATHEW, Hedley Hill Colliery, Waterhouses, Co. Durham ...	Feb. 12, 1898
26	DAYKIN, GEORGE, 116, High Gurney Villa, near Bishop Auckland	July 14, 1896
27	DIXON, JOSEPH A., Ravensworth Road, Dunston-upon-Tyne	Feb. 15, 1896
28	DORMAND, R. B., Waldridge Colliery, Chester-le-Street ...	Dec. 9, 1893
29	DRAPER, WILLIAM, New Seaham Colliery, Sunderland	Dec. 14, 1889
30	DUNNETT, SAMUEL, 32, Dale Street, North Blyth, Northumberland ...	June 8, 1895
31	ELTRINGHAM, G., Eltringham Colliery, Prudhoe-upon-Tyne, R.S.O. ...	Dec. 8, 1894
32	ELVES, EDWARD, Middridge Colliery, Heighington, R.S.O., Co. Durham ...	June 13, 1896
33	FAIRS, JOHN, 35 and 37, Laygate Lane, South Shields ...	Oct. 14, 1893
34	FAWCETT, EDWARD, 27, Eastbourne Gardens, Walker-upon-Tyne ...	June 11, 1892
35	FEWSTER, JOHN, 4, Belgrave Terrace, Felling, R.S.O., Co. Durham	Feb. 13, 1897
36	FORSTER, J. H. B., Cramlington Colliery, Northumberland	S. Nov. 24, 1894 A. Aug. 7, 1897
37	FOSTER, JOHN WILLIAM, Whitburn Colliery, South Shields	Dec. 14, 1889
38	GORDON, GEORGE STOKER, Louisa Terrace, West Stanley ...	Feb. 15, 1896
39	HAMPSON, ALEXANDER, St. Helen's Colliery, Bishop Auckland ...	Feb. 12, 1898
40	HANDYSIDE, WILLIAM, Jun., Ravensworth Avenue, Dunston-upon-Tyne ...	June 12, 1897
41	HARE, GEORGE, Seghill Colliery, Northumberland	Feb. 12, 1898
42	HARLE, R. A., Wallsend Colliery, Wallsend-upon-Tyne ...	April 14, 1894
43	HEDLEY, A. M., Medomsley, R.S.O., Co. Durham	Nov. 24, 1894
44	HENDERSON, WILLIAM, Wheatley Hill Colliery, *via* Trimdon Grange ...	Aug. 5, 1893
45	HENRY, JAMES, Howgill Staith, Whitehaven	June 8, 1895
46	HERRON, EDWARD, Holly Terrace, Stanley, R.S.O.	Feb. 15, 1896
47	HINDMARCH, JOHN, Isabella Pit, Newsham, Blyth	Aug. 3, 1895
48	HOBSON, MOSES, Shildon, *via* Darlington	Aug. 5, 1893
49	HODGSON, E., Black Boy Colliery, Bishop Auckland ...	Aug. 6, 1892
50	HORNSBY, DEMSTER, Herrington Pit, New Herrington, Fence Houses...	Feb. 12, 1898
51	HUGHES, JAMES NICHOLSON, Hedley Hill Colliery, Waterhouses, Co. Durham	Feb. 12, 1898
52	HUNTER, A., Felling Colliery, near Newcastle-upon-Tyne...	Feb. 13, 1897
53	HUNTER, CHRISTOPHER, 18, Stanley Street, Blyth, Northumberland	Dec. 10, 1892
54	JAMES, ALEXANDER A., Croxdale, near Durham	June 10, 1893
55	JOHNSON, WILLIAM, Framwellgate Moor, Durham	Aug. 6, 1892
56	KELLETT, ROBERT, Littletown, near Durham	Feb. 12, 1898
57	LIGHTLEY, JOHN, Front Street, Sherburn Colliery, Durham	April 25, 1896
58	LINDAY, ROBERT, 3, Sebastopol Terrace, Seaham Harbour	Dec. 8, 1894
59	LISHMAN, T. A.	S. Nov. 24, 1894 A. Aug. 7, 1897
60	LITTLE, WILLIAM, Linton Colliery, Morpeth	Feb. 12, 1898
61	LITTLEJOHN, ALBERT, Mount Kembla Colliery, Wollongong, New South Wales	S. Nov. 24, 1894 A. Aug 7, 1897
62	MACKINLAY, EDWARD, 20, Fourth Street, Heworth Village, Felling, R.S.O., Co. Durham	June 11, 1892
63	MACKINTOSH, THOMAS, Watt's Farm, Blyth	April 11, 1891

		Date of Election and of Transfer.
64	MANDERSON, JOHN TOM, Labuan and Borneo, Limited, Labuan, Borneo	Feb. 13, 1897
65	MARR, JAMES HEPPELL, Birtley, Chester-le-Street	Feb. 13, 1897
66	MARSHALL, JOHN, Cheetham Lane, Swinton, near Manchester	Feb. 12, 1898
67	MASCALL, W. H., Meadow View, Etherley Lane, Bishop Auckland	S. Nov. 5, 1892 A. Aug. 7, 1897
68	MASON, BENJAMIN, Burnopfield Colliery, Burnopfield, R.S.O., Co. Durham	April 11, 1891
69	MILBURN, WILLIAM, Cornsay House, Cornsay, Durham	June 8, 1895
70	MILLER, J. H., South Hetton, Sunderland	Dec. 8, 1894
71	MINTO, GEORGE WILLIAM, 2, Chapel Row, Ouston, Chester-le-Street	Oct. 10, 1891
72	MORDY, WILLIAM, Ardyngnook, West Lane, Baildon, Yorkshire	S. April 11, 1891 A. Aug. 3, 1895
73	NAISBIT, JOHN, No. 48, Tudhoe Colliery, Spennymoor	April 27, 1895
74	OWEN, WILLIAM ROWLAND, 32, Duke Street, Millom, Cumberland	Feb. 12, 1898
75	PARKINSON, W., 6, Ivy Terrace, South Moor, Chester-le-Street	June 13, 1891
76	PEDELTY, SIMON, Clara Vale, Ryton-upon-Tyne	Dec. 10, 1892
77	PRATT, G. ROSS, Springwell Colliery, Gateshead-upon-Tyne	June 8, 1895
78	PRATT, MILES, 33, Black Boy, *via* Bishop Auckland	July 14, 1896
79	PROCTOR, THOMAS, Woodhorn Colliery, Morpeth	Oct. 13, 1894
80	RAMSAY, JOHN, Tursdale Colliery, Ferryhill	April 27, 1895
81	RAMSAY, J. G., Page Bank Colliery, *via* Spennymoor, Co. Durham	Dec. 10, 1892
82	RIDLEY, GEORGE D., Tudhoe Colliery, Spennymoor	Feb. 8, 1890
83	RIVERS, JOHN, Bow Street, Thornley Colliery, Durham	Feb. 9, 1895
84	ROBSON, ROBERT, 2, Thornley Terrace, Tow Law, R.S.O., Co. Durham	Oct. 12, 1895
85	ROBSON, WILLIAM, Jun., West Hunwick Colliery, Hunwick, R.S.O., Co. Durham	S. June 11, 1892 A. Aug. 3, 1895
86	SANER, CHARLES B., Mine Office, Rietfontein, South African Republic	April 10, 1897
87	SCOTT, E. CHARLTON, 20, Henrietta Street, Swansea	Oct. 8, 1892
88	SEVERS, WILLIAM, Beamish View, *via* Chester-le-Street	Nov. 5, 1892
89	SHAW, JOHN, Belmont Villa, Chapeltown, near Sheffield	April 11, 1891
90	SIMPSON, NELSON ASHBRIDGE, Bradley Hall, Wylam-upon-Tyne	S. Aug. 1, 1891 A. Aug. 7, 1897
91	SOUTHERN, JOHN, Heworth Colliery, Newcastle-upon-Tyne	Dec. 14, 1889
92	SPRY, JOHN, Murton Colliery, Durham	Feb. 11, 1893
93	STEPHENSON, WILLIAM, Hewitson Terrace, Felling, R.S.O., Co. Durham	Dec. 13, 1890
94	STOKOE, JAMES, 10, The Avenue, Murton Colliery, Co. Durham	Nov. 24, 1894
95	SWALLOW, F. C., Ynscedwyn Colliery, Ystradgynlais, Swansea	April 14 1894
96	TARBUCK, HAROLD, Pemberton Collieries, near Wigan, Lancashire	Feb. 15, 1896
97	THOMPSON, JOHN W., Greenfield House, Crook, R.S.O., Co. Durham	June 10, 1893
98	THOMPSON, JOSEPH	April 8, 1893
99	TURNER, GEORGE, Cornsay Colliery, Co. Durham	June, 8, 1895
100	URWIN, JOHN, Inkerman House, Usworth Colliery	Feb. 15, 1896
101	WALTON, MATTHEW, Dearham Colliery, Carlisle	Dec. 14, 1889
102	WATSON, THOMAS, East Hedley Hope, Tow Law, R.S.O.	Aug. 3, 1895
103	WILSON, R. G., Pelton Colliery, Chester-le-Street	Aug. 6, 1892

STUDENTS.

		Date of Election.
1	ALLPORT, E. A., 89, Dodworth Road, Barnsley, Yorkshire ...	April 14, 1894
2	ARCHER, M. W., High Priestfield, Lintz Green, Co. Durham ...	June 8, 1895
3	BELL, WILLIAM, Elswick Collieries, Newcastle-upon-Tyne ...	Feb. 13, 1897
4	BOOTH, F. L., Ashington Colliery, Morpeth ...	Feb. 10, 1894
5	BURNE, CECIL A., Langley Park Colliery, Durham	Aug. 4, 1894
6	COWAN, H. D., Elswick Collieries, Newcastle-upon-Tyne ...	Jan. 19, 1895
7	COXON, WILLIAM B., Langley Park Colliery, Durham	Feb. 12, 1898
8	DENTON, JOHN, Montgomery Chambers, Hartshead, Sheffield ...	June 21, 1894
9	DIXON, GEORGE, Trimdon Grange, Co. Durham	June 13, 1896
10	FALCON, MICHAEL, 23, Cemetery Road, Treorchy, South Wales ..	Oct. 13 1894
11	GREENE, CHARLES C., South Durham Colliery, Eldon, Bishop Auckland	Feb. 15, 1896
12	GRIFFITH, N. M., c/o Broughton and Plas Power Coal Company, Limited, Wrexham...	Nov. 24, 1894
13	HALL, JOSEPH PERCIVAL, Cornsay Colliery, Durham	Oct. 9, 1897
14	HETHERINGTON, J. R., c/o Mr. Burnley, Sisters Villas, Garforth Colliery, near Leeds	Aug. 4, 1894
15	HOLLIDAY, NORMAN STANLEY, Langley Grove, Durham	April 10, 1897
16	JAEGER, BERNARD, c/o Mr. Kollman, Zeche Hasenwinkel, Dahlhausen a. d. Ruhr, Germany	June 12, 1897
17	JONES, WILLIAM, East Hetton Colliery, Coxhoe, R.S.O., Co. Durham	Aug. 4, 1894
18	KING, FRED. I, Shankhouse Row, Shankhouse, near Cramlington, Northumberland	Oct. 8, 1892
19	LATIMER, HUGH, South Durham Colliery, Eldon, Bishop Auckland	Feb. 15, 1896
20	MCGOWAN, ERNEST, c/o Griffith and Company, 14, Royal Arcade, Newcastle-upon-Tyne	Oct. 13, 1894
21	MIDDLETON, H. W., Trimdon Grange Colliery, Trimdon Grange, R.S.O., Co. Durham	Aug. 4, 1894
22	MINNS, THOMAS TATE, Jun., Greenhill House, Murton Colliery, Sunderland	April 10, 1897
23	MURRAY, FRANK DOUGLAS, 9, Stratton Street Piccadilly, London, W.	Aug. 7, 1897
24	MUSGROVE, WILLIAM, Throckley Colliery Office, Throckley Colliery, near Newcastle-upon-Tyne	June 8, 1895
25	NESBIT, JOHN STRAKER, Cramlington Collieries, Northumberland	Oct. 9, 1897
26	NISBET, NORMAN, 17, Latimer Street, Tynemouth...	Nov. 24, 1894
27	NOBLE, ALGERNON, c/o The Griff Colliery Company, Limited, Nuneaton	Oct. 14, 1893
28	PARRINGTON, T. E., Hill House, Monkwearmouth	Aug. 3, 1895
29	PEEL, J. W., Etherley, Bishop Auckland	Aug. 4, 1894
30	PETERKIN, JOHN ALEXANDER, 13, Swinley Road, Wigan, Lancashire	June 12, 1897
31	RAINE, FRED. J., Cornsay Colliery, Co. Durham	Feb. 15, 1896
32	RICHARDSON, NICHOLAS, Heworth Colliery, Felling, R.S.O., Co. Durham	Dec. 12, 1896
33	RICHARDSON, SYDNEY, South Pelaw Colliery, Chester-le-Street ...	Oct. 9, 1897
34	ROUTLEDGE, ROBERT, Murton Colliery, near Sunderland... ...	Feb. 13, 1897
35	SAMPLE, J. B., Tanfield Lea, Tantobie, R.S.O., Co. Durham ...	Jan. 19, 1895
36	SEVERS, JONATHAN, Stanley, R.S.O., Newcastle-upon-Tyne ...	June 8, 1895

		Date of Election
37	Simpson, R. R., 11, Haldane Terrace, Jesmond, Newcastle-upon-Tyne	Aug. 3, 1895
38	Simpson, Thomas V., Heworth Colliery, Felling, R.S.O., Co. Durham	Dec. 14, 1895
39	Snowdon, Thomas, Jun., Oakwood, Cockfield, R.S.O., Co. Durham	June 12, 1897
40	Southern, Stephen, Heworth Colliery, Felling, R.S.O., Co. Durham	Dec. 14, 1895
41	Stratton, H. S., West Cramlington Collieries, Northumberland	Feb. 9, 1895
42	Swallow, W. A., Tanfield Lea, Tantobie, R.S.O., Co. Durham	Dec. 9, 1893
43	Tate, W. O., Trimdon Grange, Co. Durham	Oct. 12, 1895
44	Thornton, Norman, Pelton Colliery, Chester-le-Street	April 27, 1895
45	Tweddell, John Smith, Seaton Delaval Colliery, Northumberland	Feb. 13, 1897
46	Walton, Arthur John, Seghill Colliery, Northumberland	Feb. 12, 1898
47	Waters, Edward, Throckley Colliery, Newcastle-upon-Tyne	April 14, 1894
48	Welsh, Arthur, 3, Model Street, New Seaham Colliery, Sunderland	Aug. 1, 1896
49	White, Harold E., Cornsay Colliery, near Durham	Oct. 10, 1896
50	Wilbraham, Arthur G. B., Anglo-American Club, Freiburg, Saxony, Germany	Dec. 11, 1897
51	Willis, Henry Stevenson, Whickham, R.S.O., Co. Durham	Feb. 13, 1892

SUBSCRIBERS.

1 Owners of Ashington Colliery, Newcastle-upon-Tyne.
2 Birtley Iron Company (3), Birtley.
3 Bridgewater Trustees (2), Bridgewater Offices, Walkden, Bolton-le-Moors, Lancashire.
4 Marquess of Bute. Bute Estate Offices, Aberdare, South Wales.
5 Butterknowle Colliery Company, Darlington.
6 Cowpen Coal Company, Limited (2), F, King Street, Newcastle-upon-Tyne.
7 Earl of Durham (2), Lambton Offices, Fence Houses.
8 Elswick Coal Company, Limited, Newcastle-upon-Tyne.
9 Hetton Coal Company (5), Fence Houses.
10 Joicey, James, and Company, Limited (2), Newcastle-upon-Tyne.
11 Lambton Collieries, Limited (2), E, Queen Street, Newcastle-upon-Tyne.
12 Marquis of Londonderry (5), c/o V. W. Corbett, Esq., Londonderry Offices, Seaham Harbour.
13 North Brancepeth Coal Company, Limited, Crown Street Chambers, Darlington.
14 Owners of North Hetton Colliery (3), Fence Houses.
15 Ryhope Coal Company (2), Ryhope Colliery, near Sunderland.
16 Owners of Seghill Colliery, Seghill, Northumberland.
17 Owners of South Hetton and Murton Collieries (2), 50, John Street, Sunderland.
18 Owners of Stella Colliery, Hedgefield, Blaydon-upon-Tyne.
19 Owners of Throckley Colliery, Newcastle-upon-Tyne.
20 Owners of Victoria Garesfield Colliery, Victoria Garesfield Colliery, Lintz Green, Co. Durham.
21 Owners of Wearmouth Colliery (2), Sunderland.
22 Westport Coal Company, Limited (2), Manager. Dunedin, New Zealand.

ENUMERATION.

	August 6, 1898.
Honorary Members	30
Members	859
Associate Members	115
Associates	103
Students	51
Subscribers	22
Total	1,180

Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.

LIST OF COMMITTEES, 1898-99.

Finance Committee.

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Mr. W. Cochrane.	Mr. G. B. Forster.	Mr. J. G. Weeks.
Mr. J. Daglish.	Mr. J. L. Hedley.	Sir Lindsay Wood, Bart.

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Mr. W. Cochrane.	Mr. A. C. Kayll.	Mr. J. B. Simpson.
	Mr. H. Palmer.	

Reference Committee for Papers to Read.

(a) Coal Mining.

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Mr. H. Palmer.	Mr. A. L. Steavenson.	Sir Lindsay Wood, Bart.

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(d) Mechanical and Electrical Engineering.

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(f) Chemical.

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N.B.—The President is *ex officio* on all Committees.

LIST OF TRANSACTIONS AND JOURNALS OF SOCIETIES, ETC., IN THE LIBRARY.

* Exchanges. † Exchanges. ‡ Presented.

*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique, Brussels. Annuaire, complete from 1882. Bulletin, complete from vol. iii.

Acts of Parliament.

‡African Review. Complete from vol. x. *By the Publishers.*

*American Academy of Arts and Sciences, Boston. Memoirs, complete to vol. xii., parts 1 to 3, 1893. Proceedings, complete.

*American Institute of Mining Engineers, New York City. Transactions, complete from 1871.

‡American Machinist, New York, 1894 to date. *By the U.S.A. Consul.*

*American Society of Civil Engineers, New York City. Proceedings, complete from 1872. Transactions, complete from 1872.

*American Society of Mechanical Engineers, New York City. Transactions, complete from 1880.

*Annales des Mines, Paris. Mémoires, complete except series 2, 3, and 4. Lois, Décrets, etc., complete, except series 1, 2, 3, and 4.

†Annales des Mines de Belgique, Brussels. Memoires, complete.

*Annales des Ponts et Chaussées, Paris. Mémoires et Documents, complete from series 6. Lois, Décrets, etc., complete from series 6. Personnel, complete from 1881.

*Annales des Travaux Publics de Belgique, Brussels. Complete, except vols. vii. and viii.

*Anthracite Coal Operators' Association, New York. Complete from August, 1897.

Arms and Explosives, London. Complete from 1892.

*Association des Ingénieurs sortis de l'École de Liége, Liége. Annuaire, complete. Bulletin, complete.

Association of Engineering Societies, Philadelphia. Journal, vols. ii.-vi., and complete from vol. viii.

*Atti della Società Toscana di Scienze Naturali, Pisa. Memorie, complete from 1877. Processi Verbali, complete.

*Australasian Association for the Advancement of Science, Sydney, New South Wales. Reports, complete to 1895.

†Australasian Institute of Mining Engineers. Transactions, complete from vol. i.

*Barrow Naturalists' Field Club, Barrow. Complete from vol. i.

Berg- und Hüttenmännisches Jahrbuch der Bergakademien zu Leoben und Přibram und der Königlich-ungarischen Bergakademie zu Schemnitz, Vienna. Complete from vol. xxxi., 1883.

Berg- und Huettenmännische Zeitung, Leipzig. Complete from vol. xlii., 1883.

*Birmingham Philosophical Society, Birmingham. Proceedings, complete to 1893.

Board of Trade Journal, London. Complete from 1886.

Boiler Explosions Acts, 1882 and 1890, London. Reports, complete.

‡British Association for the Advancement of Science. Complete from 1831. *By the Association.*

†British Society of Mining Students, Cinderford. Journal, complete from vol. ix.

Brown's Export List, Newcastle-upon-Tyne. Complete from 1853.

‡California State Mining Bureau, Sacramento. Annual Reports of the State Mineralogist. 5th to 12th. *By the State.*

*Canadian Institute, Toronto. Annual Reports, complete from 1887. Transactions complete, except yearly volumes for 1867, 1869, 1870, 1872, and 1874-1883.

Canadian Mining Review, Ottawa. Complete from vol. xi.

Cassier's Magazine, London. Complete from vol. viii.

†Chemical and Metallurgical Society of South Africa. Proceedings, complete from vol. i. Journal, complete from vol. i.

*Chesterfield and Midland Counties Institution of Engineers, Chesterfield. Transactions, complete.

*Cleveland Institution of Engineers, Middlesbro'. Proceedings, complete from 1869.

‡Coal and Iron, London, vols. iii.-vi. *By the Publishers.*

Colliery Guardian, London. Complete from vol. ii., except vols. ix. to xiii.

‡Colliery Manager, London. Complete from 1885. *By the Publishers.*

*Colonial Museum and Geological Survey of New Zealand, Wellington. Manual of the New Zealand Coleoptera, by T. Broun, complete, parts 1-7. Meteorological Reports, except for 1884, 1886, 1887, 1888, 1889, 1890, and 1891. Studies in Biology for New Zealand Students, 1887, parts 1 and 2. Palæontology of New Zealand for 1880, parts 1, 2, and 3, and all after 4.

*Connecticut Academy of Arts and Science, New Haven. Transactions, complete, except title-page and index to vol. iv.
‡Contract Journal and Specification Record, London. Complete from vol. v. *By the Publishers.*

Digest of Physical Tests and Laboratory Practice, Philadelphia. Complete.
Dinglers Polytechnisches Journal, Stuttgart. Complete from vol. ccxlvii., 1883.
‡Durham University Calendar, Durham. Complete from 1873, except for the years 1876, 1881, 1888, and 1891. *By the College.*

Engineer, London. Complete from 1856, except vols. xxvii. to xxxii.
*Engineering Association of New South Wales, Sydney. Minutes of Proceedings, complete from 1885 to vol. ix. for 1894.
*Engineering, London. Complete from 1866, except vols. i. and ii. and vii. to xii.
Engineering Magazine, Chicago. Complete.
*Engineering and Mining Journal, New York. Complete, from vol. xx., 1875.
*Engineers' Club of Philadelphia, Philadelphia. Proceedings, complete from 1880.
‡Engineers' Gazette, London. Complete from vol. ix. *By the Publishers.*

†Federated Canadian Mining Institute. Journal, complete from vol. i., 1896.
Foreign Office Reports, London. Complete from 1886.
†Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, complete from vol. lv., except vol cxviii., part 6.

†General Mining Association of the Province of Quebec. Journal, complete to 1895.
*Geological Institution of the University of Upsala, Upsala. Bulletin, complete.
*Geological and Natural History Survey of Canada, Montreal. Complete, except Mesozoic Fossils, vol. i., part 4; and Palæozoic Fossils, all after vol. ii., part 1, except vol. iii., part 1.
*Geological Society, London. Quarterly Journal, complete from 1843.
*Geological Society of Australasia. Transactions, vol. i., parts 1 to 6, 1892.
Geological Society of South Africa. Transactions, complete from vol. i.
*Geological Survey of India, Calcutta. Memoirs, complete to 1885, except vol. i., all except part 3; vol. ii.; vol. iii., all except part 2. Records, complete.
*Geological Survey of Iowa, Des Moines. Annual Reports, complete from vol. i.
†Geological Survey of New South Wales, Department of Mines, Sydney. Records, complete from 1889 to 1895. Mineral Resources, complete from 1893.
*Geological Survey of Pennsylvania, Philadelphia. Complete to 1891.
*Geological Survey of the United States, Washington. Annual Reports, complete from vol. iii. Bulletin, complete, except title-pages and indexes for all volumes after vol. viii.
*Geological Survey of Victoria, Melbourne. Complete, except publications after Report of Progress for 1883.
*Geologiska Förening, Stockholm. Förhandlingar, complete from 1872.
*Geologists' Association, London. Proceedings, complete from 1859.
*Glückauf, Essen. Complete from 1883.

‡Indian Engineering, Calcutta. Complete from 1887. *By the Publishers.*
Industries and Iron, London. Complete from vol. xv.
*Institut Geologique du Mexique, Mexico. Boletin, complete from 1895.
*Institution of Engineers and Shipbuilders in Scotland, Glasgow. Transactions, complete from 1857, except vol. ii.
*Institution of Civil Engineers, London. Minutes of Proceedings, complete from 1837.
*Institution of Civil Engineers of Ireland, Dublin. Transactions complete from 1845, except vols. xxi. and xxii.
*Institution of Mechanical Engineers, London. Proceedings, complete from 1847.
†Institution of Mining and Metallurgy, London. Transactions, complete from vol. i.
*Institution of Naval Architects, London. Transactions, complete.
Iron and Coal Trades Review, London. Complete from vol. iii., 1869.
*Iron and Steel Institute, London. Journal, complete from 1871.

*Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië, Amsterdam. Complete from 1878.
*Jahrbuch für das Berg- und Hüttenwesen im Königreich Sachsen, Freiberg. Complete, except 1878.

*Kaiserliche Akademie der Wissenschaften, Vienna. Sitzungsberichte, complete from vol. xlix., except Mathematik, Physik, Chemie, etc., vols. lx. to lxviii.; and Mineralogie, Botanik, Zoologie, etc., vols. lxiii. to lxviii.

*Kaiserlich-königlich Geologische Reichsanstalt, Vienna. Jahrbuch, complete from 1860.
*Kaiserlich Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher, Halle. Complete from vol. xxxvi.
*Koninklijk Instituut van Ingenieurs, 's-Gravenhage. Complete from 1881.
*Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin. Annual volumes for 1880-81, 1892-95.
*Königlich Ungarische Geologische Anstalt, Budapest. Jahresberichte, from 1882. Mittheilungen, complete.
*Königliche Bayerische Akademie der Wissenschaften, München. Abhandlungen der Mathematisch-physikalischen Classe, vols. vi. and vii. Sitzungsberichte, complete.

‡Labour Gazette, London. Complete. *By the Publishers.*
‡L'Echo des Mines et de la Métallurgie, Paris. Complete from 1894. *By the Publishers.*
*Le Génie Civil, Paris. Complete from 1880.
*Liverpool Engineering Society, Liverpool. Complete from 1881.
‡Liverpool Geological Association, Liverpool. Transactions, complete from 1880 to vol. x., 1890, except vols. iv. and viii.
*Liverpool Geological Society, Liverpool. Complete from 1860.
*L'Union des Charbonnages, Mines et Usines Métallurgiques de la Province de Liége. Complete from 1872.

‡Machinery Market and Exporter. 1895-96, incomplete; complete from 1897. *By the Publishers.*
*Magyarhoni Földtani Társulat, Budapest. Földtani Közlony, complete from 1871.
*Manchester Association of Engineers, Manchester. Transactions, complete from 1887.
*Manchester Geographical Society, Manchester. Journal, complete from vol. vi.
†Manchester Geological Society, Manchester. Transactions, complete from 1840, except vols. iii., vii., and ix.
*Manchester Literary and Philosophical Society, Manchester. Memoirs, complete except all volumes in first series. Proceedings, complete from 1887.
†Massachusetts Institute of Technology, Society of Arts, Boston. Complete from vol. xi.
*Master Car-Builders' Association, Chicago. Proceedings, complete from 1882.
‡Mechanical Engineer. Vol. i., complete to date. *By the Publishers.*
*Midland Institute of Mining, Civil, and Mechanical Engineers, Barnsley. Transactions, complete from 1869.
*Mineralogical Society of Great Britain and Ireland, London. Journal, complete from 1876.
Mineral Statistics of the United Kingdom, London. Complete from 1853.
Mines, List of Plans of Abandoned Mines, London. Complete.
Mines, List of Mines Worked, London. Complete.
‡Mines and Minerals, Scranton, Pennsylvania. Complete from vol. viii. *By the Publishers.*
*Mining Association and Institute of Cornwall, Camborne. Transactions, complete to vol. iv., part 1, 1893.
‡Mining Engineering. Complete from vol. i., 1897. *By the Publishers.*
*Mining Institute of Scotland, Hamilton. Transactions, complete.
Mining Journal, London. Complete from vol. xviii.
†Mining Society of Nova Scotia, Halifax. Transactions, complete to vol. iii., 1895.

*Natural History Society of Northumberland and Durham, Newcastle-upon-Tyne. Complete from 1858.
*Naturforschende Gesellschaft zu Freiburg im Breisgau, Freiburg. Transactions, complete from 1886.
Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie, Stuttgart. Complete from 1883, except Supplement, part 1.
Newcastle Daily Journal, Newcastle-upon-Tyne. Complete from March, 1869.
†New South Wales, Annual Report of the Department of Mines. Complete from 1881.
*New York Academy of Sciences, New York. Transactions, complete from 1881, except vol. iii. Annals, complete from 1879.
*New Zealand Institute, Wellington. Transactions and Proceedings, complete, except vol. ii. (1869), vol. iii. (1870), vol iv. (1871).
*New Zealand Institute of Mining Engineers. Transactions, complete from vol. i., 1897.
*New Zealand Mines Department, Wellington. Reports, complete from 1879.
*North-East Coast Institution of Engineers and Shipbuilders, Newcastle upon-Tyne. Transactions, complete from vol. i., 1884.
*North Staffordshire Institute of Mining and Mechanical Engineers, Newcastle-under-Lyme. Transactions, complete to vol. xi.; vol. xii., parts 2 to 5; vol. xiii., parts 1 to 5.
*Nova Scotia Department of Mines, Halifax. Reports, complete to 1892, except for the year 1870.
*Nova Scotian Institute of Natural Science, Halifax, N.S. Proceedings and Transactions, vol. vi., parts 1 and 4; vol. vii., parts 2, 3, and 4; vol. viii., 1894; vol. ix., parts 1-2.

Oberhessische Gesellschaft für Natur- und Heilkunde, Giessen. Complete from 1847, except vol. iii.
Oesterreichische Zeitschrift für Berg- und Hütten-wesen, Vienna. Complete from vol. xxxi., 1883.
Official Year Book of Scientific and Learned Societies, London. Complete from 1884.
‡Ontario Bureau of Mines, Reports. Complete from 1891.

*Patent Office, London. Abridgements of Specifications, complete. Illustrated Official Journal, complete.
*Patents and Patentees of Victoria, Melbourne Indexes, complete to 1888.
*Pennsylvania State College, Centre County, Pennsylvania. Mining Bulletin, complete from vol. i.
*Philosophical Society of Glasgow, Glasgow. Proceedings, complete from 1841.
‡Practical Engineer, London. Complete from 1887.

*Reale Comitato Geologico d'Italia, Roma. Bollettino, complete from 1870, except vols. iii. and iv.
Reports to the Secretary of the Board of Trade upon the Working of the Boiler Explosions Acts, 1882 and 1890, London. Complete.
Reports of H.M. Inspectors of Mines, London. Complete from 1870.
Revista Minera, Metalúrgica, y de Ingenieria, Madrid. Complete from vol. xxxiv., 1883.
Revue de la Législation des Mines en France et en Belgique, Paris. Complete from 1834.
*Revue Technique, Paris. Complete from 1894.
†Revue Universelle des Mines, de la Métallurgie, etc., Liége. Complete, except series 1, vol. xiv. (1863).
*Rochester Academy of Science, Rochester. Proceedings, complete from vol. i.
*Royal Cornwall Polytechnic Society, Falmouth. Annual Reports, complete from 1870.
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The Library comprises over 8,000 Volumes, etc., treating of Geology, and Mining, Mechanical, and Civil Engineering.

August 1st, 1898.

CHARTER OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased): THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased): SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity: that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property: that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community: that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security: that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions: that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life: that the Society has held meetings at stated

periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected: that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life: that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain knowledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes of mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding

with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, the 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

Great Seal of the United Kingdom.

BYE-LAWS.

I.—CONSTITUTION.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

II.—QUALIFICATIONS OF MEMBERS, ASSOCIATE MEMBERS, HONORARY MEMBERS, ASSOCIATES AND STUDENTS.

3.—MEMBERS.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other

branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—Associate Members shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.

7.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

III.—Election and Expulsion of Members.

8.—Any person desirous of becoming a Member, an Associate Member, an Associate or a Student, shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. The Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein.

Any person qualified to become an Honorary Member shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner:—Each Member or Associate Member attending the meeting, at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the proper Form in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the proper Form in the Appendix, and the person elected shall send the amount of his annual subscription, or life composition, within four months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration according to the proper Form in the Appendix, and having likewise made the proper payment, shall receive a certificate of his election, according to the proper Form in the Appendix.

12.—Any Member, Associate Member, Associate or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the Institute's year, so soon as he has signed and returned a declaration according to the proper Form in the Appendix, and paid his subscription.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the first of November in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the proper Form in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the proper Form in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members or Associate Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the proper Form in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion: and if a majority of the Members and Associate Members present at such meeting (provided

the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the proper Form in the Appendix.

IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 5s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member, Associate Member, Associate or Student may, at any time, compound for all future subscriptions by a payment in accordance with the following scale :—

Under 30	years	of	age,	the sum of £31
Over 30	,,	,,	,,	27
,, 40	,,	,,	,,	24
,, 50	,,	,,	,,	21
,, 60	,,	,,	,,	17

or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

18.—In case any Member, Associate Member or Associate, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible: and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

V.—Election of Officers.

20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest

Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them ; but any such Member or Associate Member shall be eligible for re-election after being one year out of office.

Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the Ordinary General Meeting in June, and shall be the balloting list for the annual election in August. (See proper Form in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office ; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a List of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of

the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the Meeting.

26.—At Meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.

35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Member shall have power to introduce two strangers (see proper Form in the Appendix) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m. to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

I hereby approve the foregoing Bye-laws.

M. W. RIDLEY,

One of Her Majesty's Principal Secretaries of State.

Whitehall,
23rd September, 1898.

APPENDIX TO THE BYE-LAWS.

Form A. Member or Honorary Member.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....189 , being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 or 5.*]

On the above grounds, I propose him to the Council as a proper person to belong to the Institute.

Signed..... .....Member or Associate Member.

Dated this.....day of.....189 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to belong to the Institute.

..... } Two Members or Associate Members, or by Five Members or Associate Members in the case of the nomination of an Honorary Member.

[Undertaking to be signed by the Candidate.]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed .....

Dated this ..... day of ..... 189 .

[To be filled up by the Council.]

The Council, having considered the above recommendation, present A. B. to be balloted for as a ..... Member of The North of England Institute of Mining and Mechanical Engineers.

Signed ..... Chairman.

Nominated at the Ordinary General Meeting .....189 .
Passed by the Council .....189 .
Elected at the Ordinary General Meeting .....189 . Age ..... years.

FORM B. ASSOCIATE MEMBER, ASSOCIATE OR STUDENT.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the..... day of ..... 189 , being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to belong to the Institute.

Signed..... Member or Associate Member.

Dated this.....day of .....189 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to belong to the Institute.

..... } Two Members or Associate Members.

[Undertaking to be signed by the Candidate.]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed .....

Dated this.....day of..... .....189 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting .....189 .
Passed by the Council .....189 .
Elected at the Ordinary General Meeting .....189 . Age,.....years.

FORM C. TRANSFER TO MEMBER OR ASSOCIATE MEMBER.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of .....189 . at present a.. ..... of The North of England Institute of Mining and Mechanical Engineers, being desirous of becoming a.....Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 and 4.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a.....Member.

Signed.....Member or Associate Member.

Dated this..... day of.....189 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to be admitted a..... Member.

.... } Two Members or
.... } Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this..... day of.....189 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....Member of The North of England Institute of Mining and Mechanical Engineers

Signed.....Chairman.

Nominated at the Ordinary General Meeting .. ...189 .
Passed by the Council .....189 .
Elected at the Ordinary General Meeting .....189 . Age,.....years.

FORM D.

List of the names of persons to be balloted for at the Ordinary General Meeting on.....the.....day of.....189 .

MEMBERS :—

.. ..

ASSOCIATE MEMBERS :—

....

HONORARY MEMBERS :—

....

ASSOCIATES:—

.....

STUDENTS:—

.....

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

FORM E.

SIR,—I beg leave to inform you that on the .....day of..... you were elected a.....of The North of England Institute of Mining and Mechanical Engineers. In conformity with its Bye-laws your election cannot be confirmed until your first annual subscription be paid, the amount of which is £....., or, at your option, a life-composition in accordance with the following scale:—

Under 30 years of age	...	...	...	...	...	£31
Over 30	,,	,,	...	...	...	27
,, 40	,,	,,	...	...	...	24
,, 50	,,	,,	...	...	...	21
,, 60	,,	,,	...	...	...	17

If the subscription is not received within four months from the present date, the election will become void under Bye-law 10.

All annual subscriptions are due on the first Saturday in August of each year.

I am, sir, yours faithfully,

Dated.....189 . .....Secretary.

FORM F.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

Founded 1852. Incorporated by Royal Charter, A.D. 1876.

These are to certify that A. B. [Christian Name, Surname, Occupation, and Address in full] was elected a Member of The North of England Institute of Mining and Mechanical Engineers, at an Ordinary General Meeting held on the .....day of.....189 .

Witness our hands and seal this..... day of..... 189 .

(Seal)

.....President.

.....Secretary.

FORM G.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £.....of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,

.....Secretary.

Dated.....189 .

FORM H.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £.....is made previous to the.....day of.....next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, sir, yours faithfully,

.....Secretary.

Dated.....189 .

FORM I.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.

I am, sir, yours faithfully,

.....Secretary.

Dated..... .....189 .

FORM J.

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of The North of England Institute of Mining and Mechanical Engineers, held on the.....day of.....189....., according to the provisions of Bye-law 15, you have ceased to be a.....of the Institute.

I am, sir, yours faithfully,

.....Secretary.

Dated .. .. .. 189 .

FORM K, BALLOTING LIST.

Ballot to take place at the Annual Meeting on.....189.....at Two o'clock, p.m.

The names of persons for whom the voter does *not* vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.

PRESIDENT—Not more than ONE NAME to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.*

_____ } New Nominations.*
_____ }

VICE-PRESIDENTS—Not more than SIX NAMES to be returned, or the vote will be lost.

The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

_____ } Vice-Presidents for the current year eligible for re-
_____ } election.
_____ }

_____ }
_____ } New Nominations.
_____ }

COUNCIL—Not more than EIGHTEEN NAMES to be returned, or the vote will be lost.

_____ }
_____ }
_____ }
_____ }
_____ }
_____ } Members of the Council for the current year eligible for
_____ } re-election.
_____ }
_____ }
_____ }
_____ }
_____ }
_____ }

_____ }
_____ }
_____ } New Nominations.
_____ }
_____ }

Any list returned with a greater number of Names than ONE PRESIDENT, SIX VICE-PRESIDENTS, or EIGHTEEN COUNCILLORS, Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

* To be inserted when necessary.

EX-OFFICIO MEMBERS of the Council for the ensuing year:—

_____ }
_____ } Past-Presidents.
_____ }

_____ }
_____ } Retiring Vice-Presidents.
_____ }

Bye-law 21.

Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the ordinary General Meeting in June, and shall be the balloting list for the annual election in August. [See proper Form in the Appendix.] A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20:—

AS PRESIDENT .....

AS VICE-PRESIDENTS .....

AS COUNCILLORS .....

FORM L.

Admit .....
of .....
to the Ordinary General Meeting on Saturday, the .....
(Signature of Member, Associate Member, Associate or Student) .....

The Chair to be taken at Two o'clock p.m.

I undertake to abide by the Bye-Laws of The North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor) .....

Not transferable.

TN
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v. 47

North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne

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